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TRAINING EFFECTIVENESS EVALUATION OF THE VESUB TECHNOLOGY DEMONSTRATION SYSTEM

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13. ABSTRACT (*Maximum 200 words*)
This report documents the Training Effectiveness Evaluation (TEE) of the Virtual Environment for Submarine OOD Ship Handling Training (VESUB) technology demonstration system. A two-phase TEE was conducted at the Submarine Training Facility, Norfolk, VA and the Naval Submarine School, Groton, CT using Navy trainees ranging in experience from Junior Officers to qualified OODs and Commanding Officers. Forty-one subjects with various experience levels were trained on three scenarios in the VESUB system: an orientation scenario for familiarization on system capabilities; a training scenario which targeted several ship handling tasks; and a testing scenario where their improvement on these tasks was measured. Data were collected on fifteen variables grouped into seven ship handling skill categories. Significant learning was found on eleven of the fifteen variables for trainees at all experience levels. For example, trainees improved 39% in checking range markers, 33% in visually checking the rudder; 57% in contact management; 44% in reaction time in a man overboard event; and 40% in using correct commands in a yellow sounding event. This is a strong indication that VESUB can effectively provide both introductory and refresher training. Conclusions and recommendations are provided.

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EXECUTIVE SUMMARY

PROBLEM

In recent years, virtual reality (VR), often called virtual environments (VE), has received an enormous amount of attention among training developers. This is due in part to media hyperbole over applications of VR in the entertainment industry, but even more so, because training developers recognize the potential of VR as a flexible and effective training medium. Training effectiveness evaluations (TEEs) of VR training systems can help define the appropriate use of VR technologies to achieve this potential.

A prime candidate for examining the effectiveness of VR systems is the training of ship handling for the surfaced submarine. Although land-based simulator facilities currently exist for training Submarine Piloting and Navigation teams, these systems do not provide detailed harbor and channel ship handling training for the Officer of the Deck (OOD). OOD training is primarily obtained from on-the-job experience, which is adversely impacted by the operational constraints of the Submarine Force, and the limited surfaced steaming time of submarines. Training that will expose junior officers (JOs) to a variety of geographical and environmental conditions is very limited since most Commanding Officers place their most experienced OODs on watch during these challenging evolutions. Therefore, an alternative simulation-based training capability is needed. A VR-based simulation may provide this necessary capability if it is shown to be an effective training approach.

OBJECTIVE

The objective of the Virtual Environment for Submarine OOD Ship Handling Training (VESUB) project was threefold: (1) to develop, demonstrate, and evaluate the training potential of a stand-alone virtual reality-based system for OOD training; (2) to determine if this system can be integrated with existing Submarine Piloting and Navigation (SPAN) training simulators, and (3) to determine the viability of virtual reality technology as a training tool. This report documents a two-phased TEE of the VESUB technology demonstration system at Submarine Training Facility (SUBTRAFAC), Norfolk, VA and the Naval Submarine School (NAVSUBSCOL), Groton, CT. The results of the TEE, as documented in this report, will be used in conjunction with the Instructor Station usability analysis (documented in a separate publication; Hays, Seamon, & Bradley, 1997) to help ensure that the design of the follow-on operational VESUB system can incorporate the latest technologies, be as user-friendly as possible, and apply the most effective training methods and techniques.

APPROACH

A two-phased TEE was conducted using Navy personnel as subjects. The first phase was conducted during a three week period at SUBTRAFAC, Norfolk, VA and the second during another three week period at NAVSUBSCOL, Groton, CT. At each site, the VESUB system was set up in a room where the TEE could be conducted without interfering with ongoing training at the training commands. Forty-one evaluation participants experienced three VESUB scenarios: the first, was an orientation scenario to allow them to experience and practice system functionality; the second, was a training scenario which targeted several specific ship handling tasks (derived from a perceptual and cognitive task analysis); and the third, was a comparable scenario to test the trainees' improvement on these ship handling skills. Prior to the first scenario, demographic data were collected and a "comfort" questionnaire was administered to assess the participants' physical condition. After completion of each scenario, a post-experience "comfort" questionnaire (with identical elements) assessed any physical changes experienced by the participants. Finally, each participant provided an assessment of the VESUB system and recommendations for its use and improvement.

RESULTS

Data were collected on fifteen ship handling variables grouped into seven skill categories. A mixed factorial analysis of variance (ANOVA) design, with experience as the between-subjects variable and scenario session (training and testing) as the within subjects variable, found significant learning (skill improvements) for all experience levels (0 to 14 years) on eleven of the fifteen variables. For example, trainees improved:

- 39% in checking range markers
- 33% in visually checking the rudder
- 13% in issuing correct turning commands
- 57% in contact management skills
- 44% in reaction time during a man overboard (MOB) event
- 29% in using correct commands during the MOB event
- 40% in using correct commands during a yellow sounding event

No major simulator side effects problems were found in the TEE, even though trainees averaged almost two hours in the head-mounted display. Details on these and other data are presented in the report, as are the results of opinion questionnaires administered to both trainees and observers.

CONCLUSIONS AND RECOMMENDATIONS

The results of the TEE strongly demonstrate that the VESUB technologies can provide effective training on ship handling skills for both novices and experts. It is recommended that VESUB move forward toward the procurement of an operational system. It is also recommended that an event-based training curriculum be developed to train the perceptual and cognitive skills required for ship handling.

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INTRODUCTION

PROBLEM

In recent years, virtual reality (VR), sometimes called virtual environments (VE), has received an enormous amount of attention among training developers. This is due in part to media hyperbole over applications of VR in the entertainment industry, but even more so, because training developers recognize the potential of VR as a flexible and effective training medium. Training effectiveness evaluations of VR training systems can demonstrate the effectiveness of VR technologies and also, how to optimally use them in existing and future training programs. The Virtual Environment for Submarine OOD Ship Handling Training (VESUB) technology demonstration system provided an opportunity to evaluate the training effectiveness of a VR-based training system in an operational context, using personnel like those who will eventually train with the operational (follow-on) VESUB system and other future VR-based training systems.

OBJECTIVE

This is the second in a series of reports to document the results of the VESUB project. It provides the results of a two-phased training effectiveness evaluation (TEE) of the VESUB technology demonstration system at two Navy training facilities: the Submarine Training Facility (SUBTRAFAC), Norfolk, VA; and the Naval Submarine School (NAVSUBSCOL), Groton, CT. This report will be used in conjunction with a previous publication (Hays, Seamon, and Bradley, 1997), which documented the usability analysis of the VESUB Instructor/Operator Station (IOS), in the development of the specifications for the operational VESUB system and to support recommendations for how to optimally use these VR training technologies. A third report in this series will document the lessons learned from the project. It is hoped that these reports will provide guidance to increase the training effectiveness of future VR training systems.

ORGANIZATION OF THE REPORT

The Background Section provides: 1) a description of the submarine ship handling task and the training requirement for the VESUB training system; 2) a brief overview of VR training research and an explanation of why submarine ship handling was chosen as the technology demonstration task.; and 3) a short description of the VESUB project. A functional description of VESUB is included to provide a context for the reader. Next, is an overview of the perceptual and cognitive task analysis that guided the hardware, software, and instructional capabilities of the system. Short descriptions of the developmental phases of the project and the scenario construction approach complete the Background Section. The Method Section describes the subjects, equipment, materials, and procedures used in the TEE and the Results Section provides analyses of the data collected during the TEE. The Discussion Section provides in-depth explanations of the data and their importance for ship handling training. Finally, the implications of the data and how they can guide the development of the operational VESUB system as well as, other VR-based training systems are discussed in the Conclusions and Recommendations Section.

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THE VIRTUAL ENVIRONMENT FOR SUBMARINE OOD SHIP HANDLING TRAINING TECHNOLOGY DEMONSTRATION SYSTEM (VESUB)

BACKGROUND

Land-based simulator facilities currently exist for training Submarine Piloting and Navigation teams. These systems do not, however, provide detailed harbor and channel ship handling training for the Officer of the Deck (OOD). OOD training is primarily obtained through on-the-job experience, which is adversely impacted by the operational constraints of the Submarine Force, and the limited surfaced steaming time of submarines. Training of junior officers (JOs) under a variety of geographical and environmental conditions is very limited since most Commanding Officers place their most experienced OOD on watch during these challenging evolutions. Therefore, an alternative, simulation-based training capability is needed and may be met effectively and economically using virtual reality (VR) technologies.

Research in Virtual Reality

VR has received considerable publicity in recent years from the entertainment industry (e.g., Brill, 1994; Gradecki, 1994) and the popular press (e.g., Rheingold, 1991; Kalansky, 1993; Burdea & Coiffet, 1994). VR has also generated considerable interest on the part of the military (e.g., McVey, 1993; Cook, 1994; Lampton, Knerr, Goldberg, Bliss, Moshell, & Blau, 1994; Knerr, Goldberg, Lampton, Witmer, Bliss, Moshell, & Blau, 1994) and NASA (e.g., Null & Jenkins, 1993).

Traditional military training systems have used operational equipment, large training ranges, or expensive simulation equipment. VR affords the potential to greatly reduce the cost of training systems because it can provide a trainee with an interface to training equipment without the necessity of replicating expensive hardware. Furthermore, VR training can be provided on a range of tasks using the same basic trainee interface by changing the VR software. This can potentially save significant amounts of resources which would otherwise be required to build a completely new, physically different, trainee interface. VR also offers the potential to provide new and innovative training strategies that can only be applied in a virtual world. For example, a trainee could view the inside of a fuel system from the perspective of a molecule of gasoline; he or she could grow to the size of a giant to view a tactical engagement from above, then jump from one ship to another for various points of view; or a trainee could engage in team training with virtual team members. However, the potential of VR training can not be achieved unless researchers explore the complex nature of this training medium and demonstrate, evaluate, and enhance the effectiveness of VR training systems.

Research in VR is being conducted at various laboratories (e.g., the Army Research Institute, and the Navy Post Graduate School) in three modality areas: visual, auditory, and haptic. Visual research includes efforts to improve display devices (e.g., head-mounted displays [HMDs] and "cave" projection screens) and head tracking systems. The visual modality is the most highly advanced area of VR research. Auditory research is examining the effectiveness of the use of highly realistic and 3-D localized sounds in virtual worlds. Research on haptic interfaces seeks to improve the representation of both the tactile (cutaneous) and kinesthetic (muscle and joint) aspects of virtual touch. Because the haptic area is the least mature of the three VR modalities, a task was sought that did not require a haptic interface. As discussed below, submarine ship handling was chosen as the task area for this VR technology demonstration.

The VESUB Project

VESUB was a Navy Manpower, Personnel, and Training Research and Development project with the goal to develop, demonstrate, and evaluate the training effectiveness of a VR-based system for surfaced submarine OOD training. The submarine ship handling task was chosen as the task area for the technology demonstration for three reasons: 1) there is a clear Navy need for this training; 2) submarine ship handling is a visually dependent task; and 3) the visual modality is the most mature of the three areas of VR development. If effective, VESUB has the potential to reduce the number of ship handing mishaps, save lives, and reduce property loss. Based on the results of the VESUB effort, the Navy will procure several operational VESUB systems to be installed at submarine training facilities throughout the United States.

The software and the hardware integration for the VESUB system was developed by Nichols Advanced Marine Engineering (formerly Advanced Marine Enterprises, [AME]) under contract to and direction of a research team at the Naval Air Warfare Center Training Systems Division (NAWCTSD) in Orlando, Florida. The research team included: Research Psychologists, Visual Engineers, Computer Engineers, and submarine Subject Matter Experts (SMEs). To save time and money, VESUB was developed by leveraging AME's Virtual Ship, a commercial product that has been used for several years to train surface ship handling tasks.

Under the VESUB project, AME has modified Virtual Ship by replacing its large projection screen system with head-mounted display (HMD) and magnetic head tracking technologies to present the visual scene to trainees. The VESUB project has also required AME to enhance the level of detail and fidelity in the visual databases far beyond that of previous systems and also to incorporate a voice recognition system for trainee interaction with the system. In addition to advancements in the hardware and software technologies used in Virtual Ship, VESUB has introduced numerous improvements to the instructor interface so it can be more easily used by Navy instructors.

VESUB SYSTEM FUNCTIONAL DESCRIPTION

The VESUB technology demonstration system uses a high-resolution HMD to provide the trainee with a simulated 360 degree visual environment containing many of the required cues associated with harbor and channel navigation as well as, accurate cultural features and varying environmental conditions. Speaker-independent voice recognition and speech synthesis are used as the trainee interface with the computer, providing communications training for this complex task. Visual scene rendering, computation of harbor currents and wind effects, and the hydrodynamic properties of own ship and other traffic ships are realistically represented. Appendix A lists and describes the hardware and software used in VESUB.

Figure 1 shows an artist's depiction of the VESUB system. On the right side of the figure, an instructor is shown seated in front of the three monitors at the Instructor/Operator Station (IOS). Screens on two of the IOS monitors are used to modify and control training scenarios. The third monitor is used to observe the virtual world that the trainee sees through the HMD during a training exercise. This view allows the instructor to evaluate the trainee's performance in real-time and provide

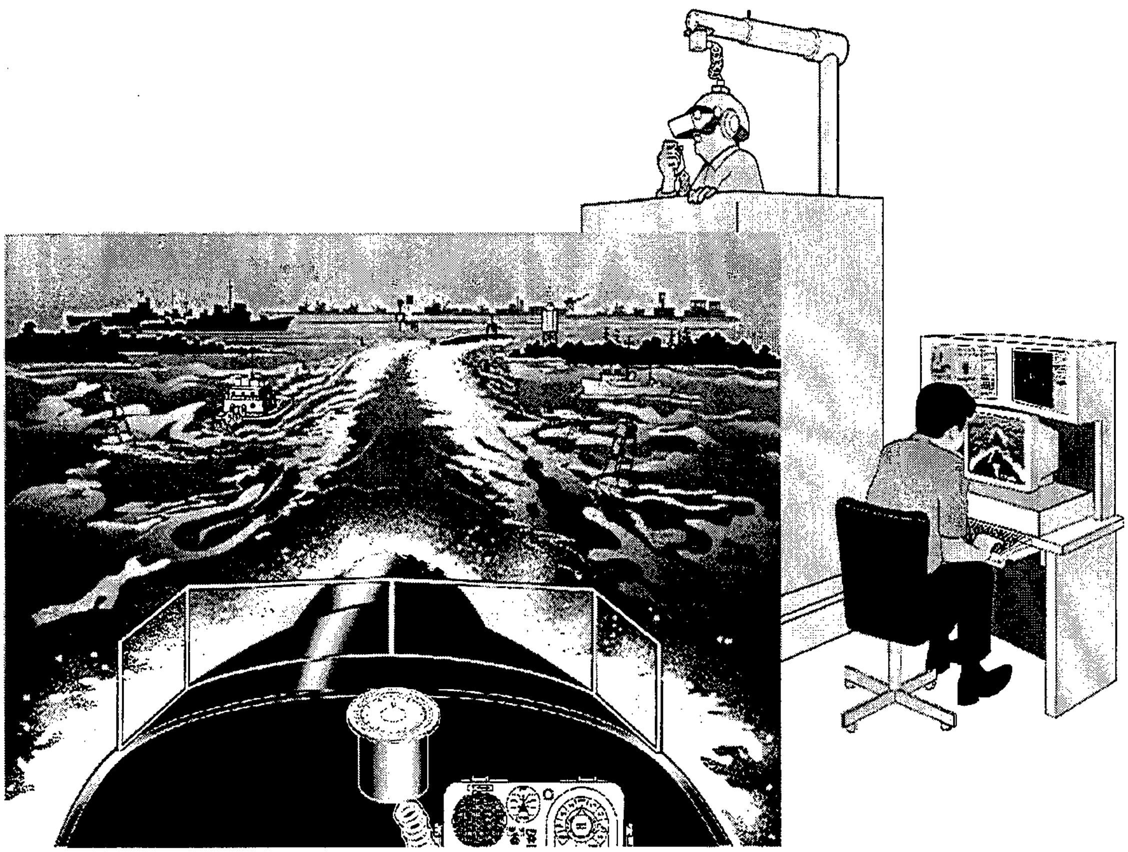

Figure 1: Artist's Representation of VESUB

guidance to direct the trainee to look for objects that support the task. This same monitor is used before an exercise to create the training scenarios. In Figure 1, the trainee is shown standing in the bridge mock-up, wearing the HMD and communicating with a simulated navigation team via a hand-held microphone. The inset depicts a typical harbor scene as the trainee views it through the HMD. The visual scene displays distant objects, including: harbor geographic features, navigation aids, landmarks, and traffic ships. It also displays objects near the trainee, including: a representation of the bridge area (for either the 688I or 726 class of submarines), and the bridge equipment and information used to help the OOD perform the ship handling task. This includes: the bridge suitcase with the rudder angle indicator and engine order telegraph; the compass repeater; a representation of a simplified harbor chart; and a course card with information on each leg of the channel. The requirement to display near and distant objects necessitated the use of new visual scene management processes (e.g., a large area database management [LADBM] system) that were not needed in previous ship handling training systems. When the trainee turns his head, a magnetic head tracker, mounted above the mock-up, senses the movement and the computer changes the visual scene appropriately. For example, the trainee is able to turn to the stern and observe the rudder move in response to an issued helm order. Visual obstacles, such as lookouts, periscopes, and radar masts can be displayed at the discretion of the instructor to make the training task more realistic by forcing the trainee to look around them to see critical visual cues.

PERCEPTUAL AND COGNITIVE ANALYSIS OF THE SUBMARINE SHIP HANDLING TASK

A submarine, when surfaced, must perform according to the ship handling procedures followed by surface ships. Current submarine OOD ship handling training, primarily conducted on-the-job, requires each ship's Commanding Officer (CO) to evaluate the performance of JOs prior to certifying them as qualified OODs. In the early phases of the VESUB project, submarine COs were interviewed to determine how they determined a JO was qualified as OOD. In almost every case, the COs responded that their personnel were qualified when they had developed the "Seaman's Eye." This concept was, therefore, used as the keystone for the analysis of the training task that the VESUB technology demonstration system had to support.

Initially, the VESUB research team viewed the ship handling task as primarily cognitive; requiring the OOD to make timely decisions about the ship's condition and issue orders to ensure its safety. However, the use of the term "Seaman's Eye" by task experts shifted the emphasis to perceptual issues. Therefore, it was reasoned that the ship handling task had to be composed of both perceptual and cognitive components. Prior to additional focused interviews with SMEs, the following definition of "Seaman's Eye" was developed to guide the perceptual and cognitive analysis of the ship handling task.

> *Seaman's Eye: The total situation awareness of the ship handling environment and the ability to safely maneuver the vessel in all conditions.*

"Seaman's Eye" includes situation awareness as an integral component. Situation awareness has been defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 1988, p. 97). This implies that in order to develop good situation awareness (e.g., "Seaman's Eye"), the individual must develop a mental model of his own ship, other ships, the environment, and the task (e.g., safely make a turn). Rouse and Morris (1986) define a mental model as a "mechanism whereby humans generate descriptions of system purpose and form, explanations of system functioning and observed system states, and predictions of future system states" (p. 360). To construct a mental model that is accurate and complete, the individual must perceive the information available in the environment (perception), and process the information to assess the current status of the environment and project the future status of the environment (cognition). Then, the mental model can be used to help the individual take appropriate actions to efficiently and effectively perform the required tasks.

The quality of an individual's situation awareness is directly dependent upon the degree of completeness and accuracy of the mental model that has been developed. The more accurate the mental model, the better the individual will be able to process critical information in an efficient and effective manner. Task performance follows a similar progression; a more accurate and complete mental model of the environment and task should lead to improved task performance. The goal of any training system (including VESUB) should be to enhance the individual's mental model of the task situation.

With this goal in mind, the definition of "Seaman's Eye" was used to guide the development of hardware, software, and instructional approaches for VESUB. However, the definition was still too general to meet this goal. Therefore, iterative probing of SMEs, using focused group discussions at Navy training facilities and in the NAWCTSD laboratory, detailed the perceptual and cognitive components that make up this complex concept. Additional group discussions with the SMEs helped the VESUB research team to organize the components as shown in Table 1.

Table 1
Components of "Seaman's Eye"

PERCEPTUAL COMPONENTS	
1P.	Locating and Identifying Navigation Aids
2P.	Judging Distance
3P.	Identifying the Start and Completion of Turns
4P.	Locating, Identifying, and Avoiding Obstacles
5P.	Sense of Ship's Responsiveness
6P.	Recognizing Environmental Conditions
7P.	Recognizing Equipment Failures
8P.	Detecting and Filtering Communications
COGNITIVE COMPONENTS	
1C.	Understanding the Relationship of Visual Cues to their Representations on Charts
2C.	Understanding Relative Size and Height/Range Relationships, and Angle on the Bow (AOB)
3C.	Understanding Advance and Transfer
4C.	Understanding the Effects of Tides, Currents, Wind, and Seas
5C.	Understanding Rules of the Road
6C.	Understanding Relative Motion (Direction and Speed)
7C.	Understanding Methods to Differentiate and Prioritize Traffic Contacts
8C.	Understanding Ship's Operation Under Harbor Directives
9C.	Understanding Methods to Deal with Uncooperative Traffic
10C.	Understanding Correct Operation of Ship's Systems
11C.	Understanding When and How to Take Corrective Actions
12C.	Understanding Effective Communication Procedures

The perceptual components of "Seaman's Eye" were initially used to determine the hardware requirements for the system. For example, the requirement to locate and identify navigation aids (1P) and to judge distance (2P) required that the trainee be able to see the objects at great distances necessitated the use of a high resolution HMD. The requirement to visually inspect the rudder necessitated the use of head tracking and rapid refresh rate of the visual scene. Details on this determination can be found in Hays, Castillo, Bradley, and Seamon (1997).

Both the perceptual and the cognitive components of "Seaman's Eye" were used to develop and organize the training objectives for the VESUB system. These training objectives, shown in Appendix B, were subsequently used to develop the training and evaluation criteria for the VESUB TEE.

VESUB DEVELOPMENT PHASES

The VESUB project proceeded in three phases: requirements determination, formative evaluations, and training effectiveness evaluations. A major tool used during the requirements determination phase was a feasibility demonstration system developed under the NAWCTSD exploratory research Virtual Environment Training Technology project. The feasibility demonstration system included a simplified harbor scene and submarine model, which was viewed through a low resolution HMD. This system afforded SMEs a chance to experience a virtual world. Questionnaires and interviews were then used to solicit detailed functional requirements for the VESUB technology demonstration system from the SMEs. These requirements were documented in a NAWCTSD special report (Tenney, Briscoe, Pew, Bradley, Seamon, & Hays, 1996) and used in conjunction with the work statement to direct the contractor during the development of the VESUB technology demonstration system.

The formative evaluation phase was conducted in the laboratory at NAWCTSD. Whenever AME delivered an improved iteration of the VESUB software, it was evaluated against the functional requirements by the VESUB research team. Data for the formative evaluations were also collected from eleven fleet and school SMEs and nine Navy reservists with ship handling experience following extensive exposure to VESUB. As soon as the formative data were collected, the results were provided to the software developers to guide system improvements. The formative evaluations focused on both the functionality of the trainee interface (e.g., the fidelity of objects in the visual scene or the functionality of the voice recognition system) and the usability of the IOS (Hays, et al., 1997).

The TEE of the VESUB technology demonstration system was conducted at the Submarine Training Facility in Norfolk, Virginia and the Naval Submarine School in Groton, Connecticut during the Winter and Spring of 1998. The TEE used Navy trainees with various levels of experience (novice to expert) to determine the effectiveness of the VESUB system and also to help determine how the technology can be integrated into Navy training.

TEE SCENARIO CONSTRUCTION

The development of the training and testing scenarios used in the TEE followed an "event-based" training approach (Johnston, Cannon-Bowers, & Smith-Jentsch, 1995; Dwyer, Fowlkes, Oser, & Lane, 1997). "The cornerstone of event-based training is a process-based performance measurement system that is linked closely to training objectives that are embedded in pre-specified scenario events" (Johnston, et al., 1995, p. 275). This approach has proven successful for training tasks in a variety of areas, including: shipboard command teams (Johnston, et al., 1995); aviation team coordination (Fowlkes, Lane, Salas, Franz, & Oser, 1994); multi-service team training, distributed among multiple remote sites (Dwyer, et al., 1997). A similar approach was followed in the development and construction of the scenarios used in the TEE.

The cognitive and perceptual components of "Seaman's Eye" (Table 1) and the training objectives derived from them (Appendix B) were used to develop the ship handling skill training events for the TEE scenarios. Eight major events were created for the training and testing scenarios:

- Position Determination
- Contact Location and Evaluation
- Getting Underway
- Maneuvering Own Ship (e.g., correct turns)
- Man Overboard
- Incorrect Navigator Report (position)
- Crossing Situation (rules of the road)
- Yellow Sounding

Details on the variables used to measure performance during these events and the perceptual and cognitive components that support them are discussed in later sections of this report. The limited time and resources available for the TEE constrained the number of ship handling skills that could be trained and evaluated. Nevertheless, this event-based approach ensured that the TEE scenarios were both instructionally sound and task relevant.

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METHOD

The two-phased VESUB TEE was conducted at the SUBTRAFAC, Norfolk, Virginia and the NAVSUBSCOL, Groton, Connecticut. Three weeks were spent at each site, including system set up and testing, data collection, and demonstrations for senior officers and other visitors.

SUBJECTS

Forty-one active duty Navy personnel participated as trainees in the TEE. They included:

- 4 Naval Officers from the staff at SUBTRAFAC, Norfolk, VA
- 1 Chief Petty Officer from the staff at SUBTRAFAC, Norfolk
- 13 Naval Officers from submarine crews in Norfolk
- 1 Senior Chief Petty Officer from the staff at Submarine Force Atlantic
- 6 Officers from the staff at NAVSUBSCOL, Groton, CT
- 6 students from the Submarine Officers Basic Course (SOBC), Groton
- 10 Junior Officers from submarine crews in Groton

Demographic information on the trainees is provided in Appendix C.

A Norfolk harbor pilot (civilian government employee) was run through the scenarios, but because of his lack of familiarity with submarine-specific procedures, only his side effects and opinion data are reported. Eleven additional persons participated in the TEE as observers. Demographics on all these observers are provided in Appendix D.

EQUIPMENT

The equipment used for the TEEs consisted of the VESUB system (see Appendix A) and two hand-held stopwatches.

MATERIALS

A scenario script was used to ensure all participants received identical information (see Appendix I for the inbound-first script). Performance data were collected using the forms shown in Appendix J. In addition, trainees and observers filled out the following questionnaires:

- A trainee demographic and background information questionnaire (see Appendix E)
- A "comfort" questionnaire, administered four times, to assess the subject's feelings on 16 physical symptoms (see Appendix F). The "comfort" questionnaires were adapted from the Simulator Sickness Questionnaire (SSQ), based on data from a factor analysis of over 1000 Navy and Marine Corps pilots in flight simulators (Lane & Kennedy, 1988; Kennedy, Lane, Berbaum, & Lilienthal, 1993). This approach has also been recommended to evaluate side effects from virtual environments (Kennedy, Lane, Lilienthal, Berbaum, & Hettinger, 1992)
- A questionnaire soliciting trainee' opinions about the system (shown in Appendix G)
- An Observer Questionnaire (shown in Appendix H)

PROCEDURE

At each TEE site, the VESUB evaluation was conducted in a dedicated room to avoid interference with or interruptions from other training classes. The research team included an "instructor" who operated the system during the evaluation scenarios, two data collectors; and one evaluation coordinator, whose job was to provide introductory briefings for the overall evaluation and for each scenario and to ensure that all procedures were conducted in the same manner for each subject. The TEE scenarios were run according to a script to ensure that all subjects received identical instructions. Subjects were randomly counterbalanced so that half received training on the inbound scenario and testing on the outbound scenario and half experienced scenarios in the opposite order.

Two subjects were evaluated each day, one in the morning and one in the afternoon. The total time for each session (including breaks) was approximately three hours. Upon arrival, each subject filled out the demographic questionnaire (Appendix C) and the first "comfort" questionnaire (Appendix F). Each subject then experienced three scenarios. The first scenario, using the Norfolk database, provided orientation to the system, demonstrations of system capabilities, and an opportunity for the subject to learn to adjust the HMD and to move about in the virtual world. He also was given an opportunity to practice interactions with the voice recognition system to: 1) learn to communicate with the virtual Helm, Navigator, and Maneuvering Watch; 2) to learn to control the binocular function, the harbor chart, and the course card. The mean duration of the orientation scenario was 22 minutes and 7 seconds. Immediately following the orientation scenario, each subject filled out the second "comfort" questionnaire.

After a short break, each subject was given a prebrief for the training scenario (Appendix I), then placed in the bridge mock-up and fitted into the HMD. The training scenario used the Kings Bay, Georgia database and was either inbound or outbound, based on random counterbalancing. The training scenario targeted several specific ship handling tasks, as described earlier. At the close of each training event, the system was paused and an instructional intervention was provided. These interventions followed the basic script shown in Appendix I, with modifications based on each subject's performance on the event. The mean duration of the training scenario was 51 minutes. At the end of the training scenario, each subject was debriefed using the performance data collected by the research team (Appendix J) and several printouts provided by the system. For example, the system produced a track plot, which showed the subject where his ship was located relative to the center of the channel and to various traffic ships throughout the scenario. The debrief also included a replay of the scenario at ten times normal speed with the subject's eye point positioned above and behind the submarine so the subject could see an overview of the channel and traffic patterns relative to own ship's actions. Following this debrief, each subject took a ten minute break.

After the break, each subject received a prebrief on the third (testing) scenario. This scenario was the reverse (inbound or outbound) of the training scenario. During the testing scenario, the subject was evaluated on comparable tasks to those that were trained in the previous scenario. The mean duration of the testing scenario was 37 minutes. Although no training interventions were provided in this scenario, each subject was fully debriefed on his performance after he had filled out the final "comfort" questionnaire and the questionnaire on his opinions about system features and possible future uses of the technology (see Appendix G). Finally, each subject was thanked for his participation and asked not to discuss the specifics of the TEE scenarios with other prospective subjects.

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RESULTS

SIMULATION SIDE EFFECTS

The raw data on simulation side effects, collected with the "comfort" questionnaire, are shown in Appendix K. Using the methods developed by Kennedy, et al. (1993), the raw scores were transformed into three subfactor scores (Nausea, **O**culomotor, and **D**isorientation) and a **T**otal **S**ide Effects Score. These transformed scores and the duration each subject was in the HMD can also be found in Appendix K. The frequency of the Total Side Effects Scores for the Pretest and after each scenario are shown in Table 2 and Figure 2.

Table 2

Frequency of Total Side Effects Scores During the VESUB TEE

	Number of Subjects After Each Scenario			
Total SSQ Score	**Pre-Test**	**Orientation**	**Training**	**Testing**
0.00	22	15	9	11
3.74	6	5	7	10
7.48	5	3	2	5
11.22	4	2	4	1
14.96	3	6	5	4
18.70	0	4	4	3
22.44	1	4	3	2
26.18	1	1	1	0
29.92	0	1	3	2
33.66	0	1	2	1
37.40	0	0	0	1
56.10	0	0	1	0
71.06	0	0	1	0

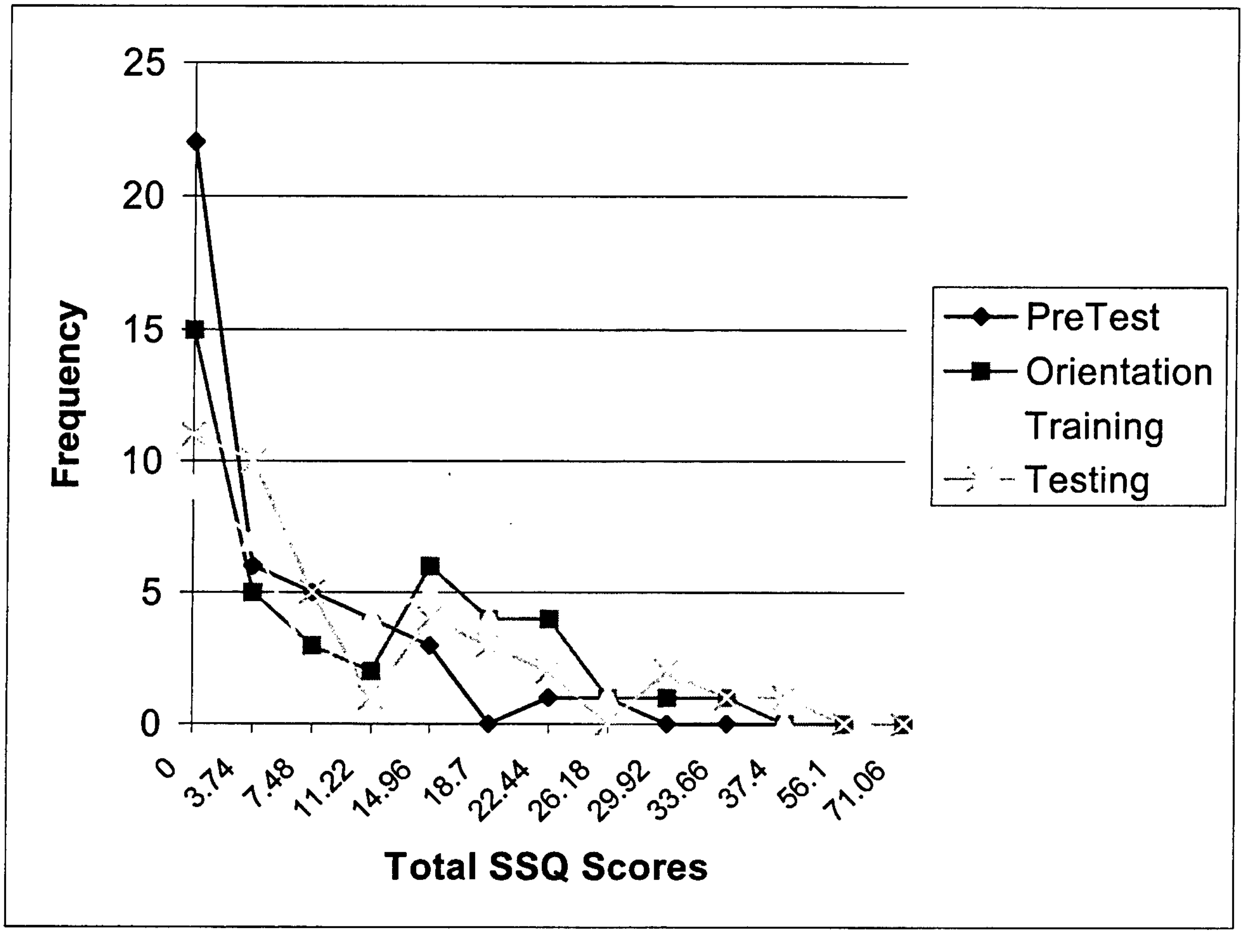

Figure 2:

Frequency of Total Simulator Side Effects Scores During the VESUB TEE

The mean values on each SSQ subfactor scale are shown in Figure 3.

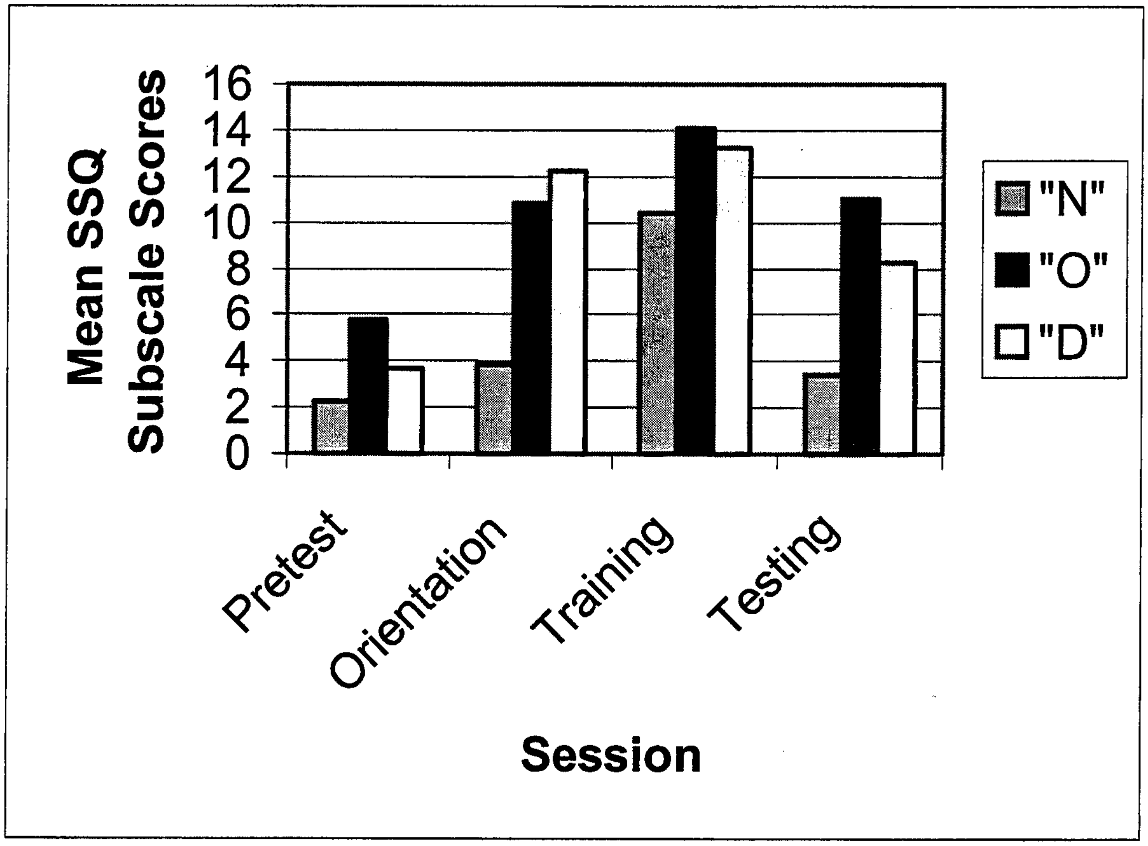

Figure 3:

Mean Scores on SSQ Subfactors During the VESUB TEE

SHIP HANDLING PERFORMANCE

The trainees' improvement on several ship handling skills was assessed by comparing their performance on selected tasks in the training scenario to their performance on comparable tasks in the testing scenario. Performance data were collected on fifteen dependent variables grouped into seven skill areas. These dependent variables and skill areas are listed and defined in Table 3. The perceptual and cognitive components of "Seaman's Eye" (see Table 1) that are most closely related to each variable are also shown in Table 3 (the most relevant components are underlined and in bold face).

A mixed factorial analysis of variance (ANOVA) design was used to analyze the data collected on the variables. The between-subjects factor was years of experience (less than one year, one to three years, and over three years). The within-subjects factor was scenario session (training or testing). To control for the repeated ANOVAs, a significance level of .01 was set for the analysis. The results of the analysis are reported according to the skill groupings from Table 3.

Table 3:
Dependent Variables Used in the VESUB TEE

Variable	Explanation of Variable	Related "Seaman's Eye" Components
Position Determination		
Position of Own Ship Across Track	Difference between the actual starting position (right or left of track) and the reported position, as determined by use of navigation aids and range markers.	**1P**, **2P**, **1C**, 2C
Position of Own Ship Along Track	Rating of subject's determination of Own Ship's position along the track (satisfactory = within 200 yds of actual position).	**1P**, **2P**, **1C**, 2C
Contact Management		
Contacts Found	Ratio of the total number of contacts found to the total number of contacts available.	2P, **4P**, 2C
Contacts "Of Concern"	Ratio of the total number of contacts identified as being of concern to the total number actually of concern, as determined by SMEs.	2P, **4P**, 2C, 5C, 6C, **7C**
General Ship Handling		
Turning Commands	Ratio of the number of correct commands given by subject when making turns to the total possible number of correct turning commands for all turns during the entire scenario.	1P, 2P, **3P**, **5P**, 1C, **3C**, 4C, 10C, **12C**
Checking the Rudder	Ratio of the number of times the subject visually checked the rudder after giving a rudder order to the total number of possible visual checks after rudder orders during the entire scenario.	**10C**
Checking Ranges	Ratio of the number of times the subject visually checked the range markers to the total possible number of times ranges should have been checked during the entire scenario, as determined by SMEs.	**1P**, 10C
Table Continued on the Next Page		

Table 3: Continued

Variable Name	Explanation of Variable	"Seaman's Eye" Components Related To
Emergency Operations		
Man Overboard Reaction Time	Time to begin corrective actions after hearing report that a man was overboard.	8P, 6C, **11C**, **12C**
Man Overboard Commands	Number of correct commands given and actions performed during MOB event.	6C, **11C**, 12C
Yellow Sounding	Total number of correct actions taken by the subject during Yellow Sounding event.	**1P**, 2P, 8P, 4C, 10C, **11C**, 12C
Incorrect Report Recognition		
Incorrect Report Recognition	Total number of correct actions taken and commands issued by the subject when given an incorrect position report by the Navigator.	**1P**, 2P, **8P**, **11C**, 12C
Communications		
Commands to Get Underway	Ratio of number of correct commands given when getting own ship underway to the total possible number of correct commands to get own ship underway during the entire scenario.	5P, 4C, **10C**, **12C**
Acknowledge Reports	Ratio of the number of scheduled reports that are acknowledged by the subject to the total possible number of required acknowledgments	**8P**, 10C, **12C**
Use Station Identifiers	Number of times the trainee failed to use station identifiers when issuing commands.	10C, **12C**
Rules of the Road		
Ferry Passage	The total number of correct commands given during the crossing situation with the ferry.	2P, **4P**, 5P, 8P, 2C, **5C**, 6C, 7C, **8C**, 10C, 11C, **12C**

Position Determination

Two variables were used to assess the trainees learning of position determination: position across the track and position along the track. Position across the track was the difference between the trainee's assessment of own ship's position and its actual position. A mixed factorial ANOVA yielded a significant main effect for scenario session, $F(1, 36) = 7.71$, $p = .009$). The mean score on this variable for the training scenario was 34.07 yards and for the testing scenario was 13.65 yards. No significant main effect was found for the between-subjects factor of experience level, $F(2, 36) = 1.05$, $p = .360$ and no significance was found for the interaction of scenario session and experience level, $F(2, 36) = .77$, $p = .471$, indicating that learning occurred across all levels of experience. Figure 4 shows a graphic representation of trainees' performance on determination of position across the track during the training and testing scenarios.

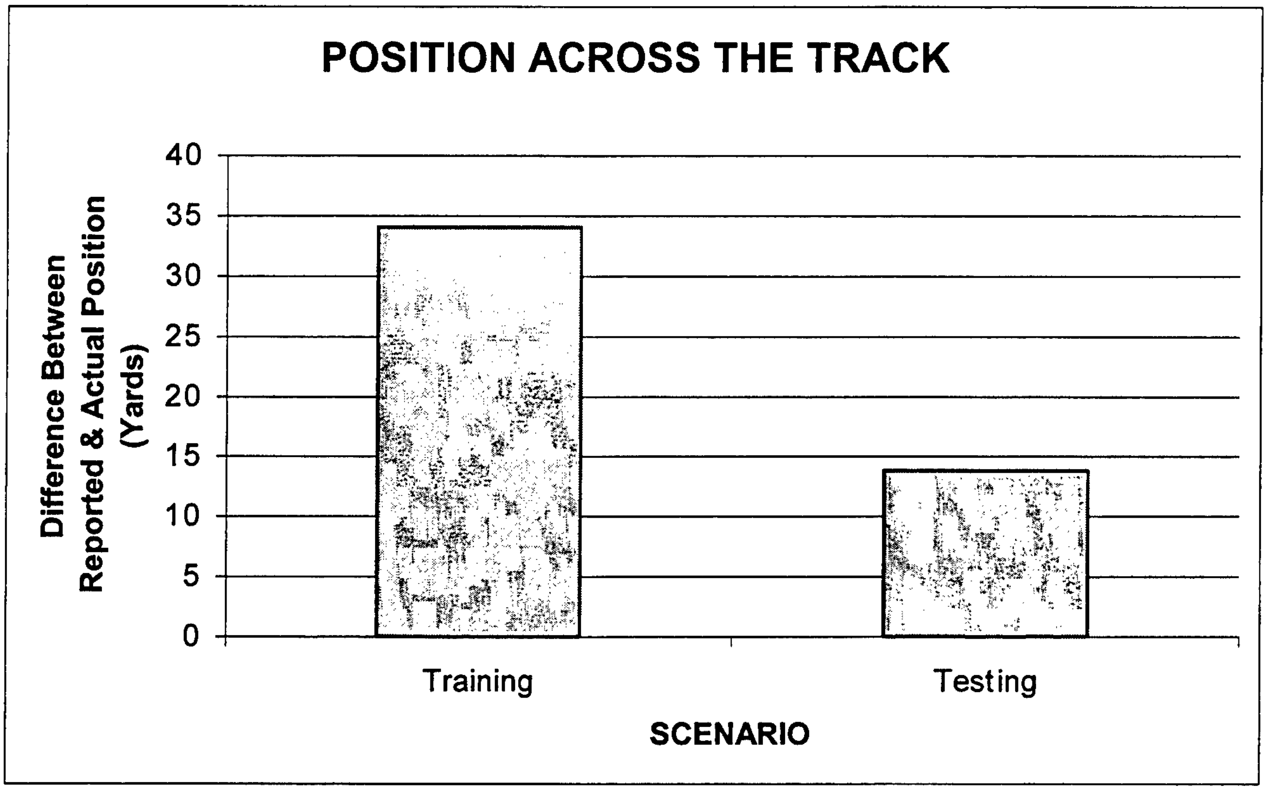

Figure 4:
Trainees' Performance on Determination of Position Across the Track During the VESUB TEE

The trainees' performance on the determination of own ship's position along the track was rated as satisfactory if a trainee's estimate was within 200 yards (approximately one Trident submarine's length) of the actual position of own ship. A mixed factorial ANOVA yielded no significant main effect for scenario session, $F(1, 36) = 1.96$, $p = .171$, no significant main effect for experience level, $F(2, 36) = .396$, $p = .676$, and no significant effect for the interaction of scenario session and experience level, $F(2, 36) = .743$, $p = .483$.

Contact Management

Two variables were used to assess the trainees' performance in the contact management skill area: Contacts Found and Contacts of Concern. Contacts found was a ratio of the total number of contacts found by the trainee when scanning the virtual world compared to the actual number of contacts present. A mixed factorial ANOVA yielded no significant main effect for scenario session, $F(1, 36) = .280$, $p = .600$. No significant main effect was found for the between-subjects factor of experience level, $F(2, 36) = .645$, $p = .531$.

A significant interaction, however, was found between scenario session and experience level, $F(2, 36) = 5.59$, $p = .008$. Figure 5 shows a graphic representation of the performance of trainees on the task of finding contacts during the training and testing scenarios.

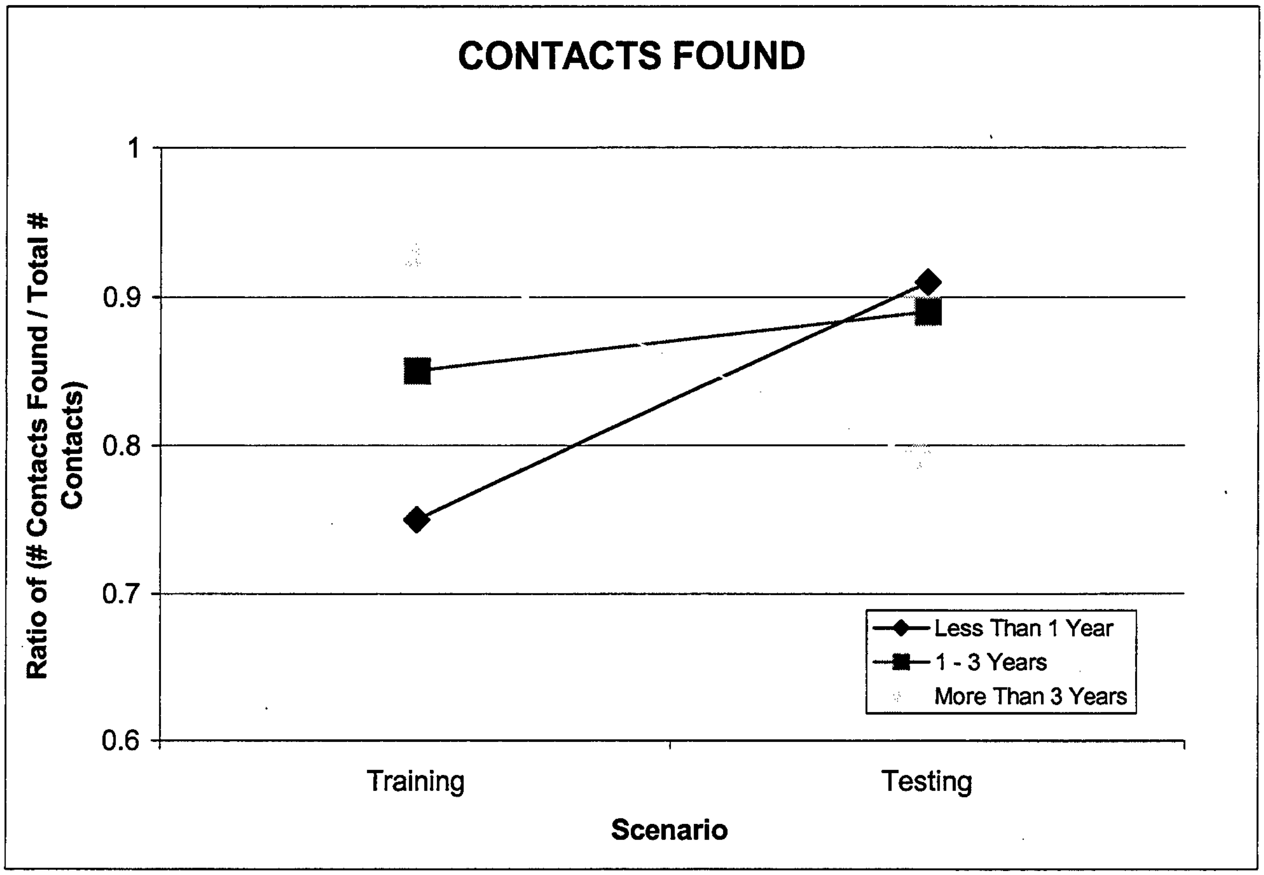

Figure 5:
Trainees' Performance on Locating Contacts During the VESUB TEE

The means for the trainees with "less than 1 year" of ship handling experience were .75 and .91 for the training and testing scenarios respectively. The means for the trainees with "1 to 3 years" of ship handling experience were .85 and .89 for the training and testing scenarios respectively. The ratio of contacts found compared to actual contacts increased for these two experience levels between training and testing indicating that learning did occur. The means for the trainees with "more than 3 years" of ship handling experience were .93 and .79 for the training and testing scenarios respectively. The ratio of contacts found compared to actual contacts decreased for this experience level indicating that learning did not occur for this group on this particular task. Possible reasons for this decline in performance in this group will be discussed later in this report.

The trainees' performance for contact management with regards to determination of which contacts should be categorized as contacts "of concern" was a ratio measure of the number of contacts found that the trainee categorized as "of concern" compared to the number of contacts in the scenario that were categorized as "of concern" by SMEs employed in development of the training and testing scenarios. A mixed factorial ANOVA yielded a significant main effect for scenario session, $F(1, 36) = 28.02$, $p = .000$. The mean score on this variable for the training scenario was .49 and for the testing scenario was .77. This indicates that out of 100% of the contacts the trainee should have identified as "of concern" in the training and testing scenarios, the trainee correctly identified 49% in the training scenario and 77% in the testing scenario. No significant main effect was found for the between-subjects factor of experience level, $F(2, 36) = 1.35$, $p = .271$ and no significance was found for the interaction of scenario session and experience level, $F(2, 36) = .689$, $p = .509$. Figure 6 shows a graphic representation of the performance of trainees on the task of identification of contacts "of concern" during the training and testing scenarios.

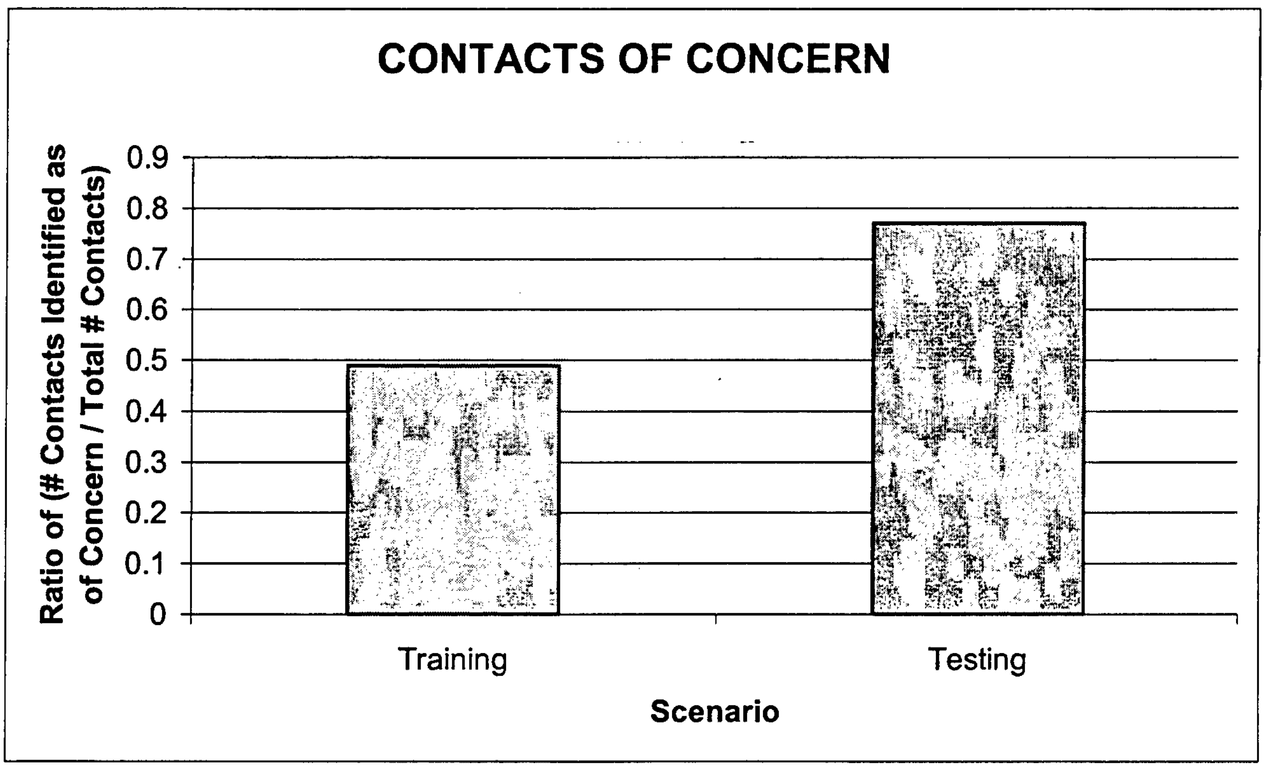

Figure 6:
Trainees' Performance on Identification of Contacts of Concern During the VESUB TEE

General Ship Handling

Three variables were used to assess the trainees learning of general ship handling: turning commands, checking the rudder and checking ranges. Turning commands was the ratio of the number of commands issued and/or actions taken associated with turning own ship that the trainees executed, during the entire scenario, compared with the number of commands issued and/or actions taken associated with turning own ship that the trainees should have executed as determined by SMEs. A mixed factorial ANOVA yielded a significant main effect for scenario session, $F(1, 36) = 17.36$, $p = .000$. The mean score on this variable for the training scenario was .75, and for the testing scenario was .85. This indicates that out of 100% of the commands and actions associated with turning own ship that the trainees should have executed in the training and testing.scenarios, the trainees correctly executed 75% in the training scenario and 85% in the testing scenario. Figure 7 shows a graphic representation of the performance of trainees on execution of turning commands during the training and testing scenarios.

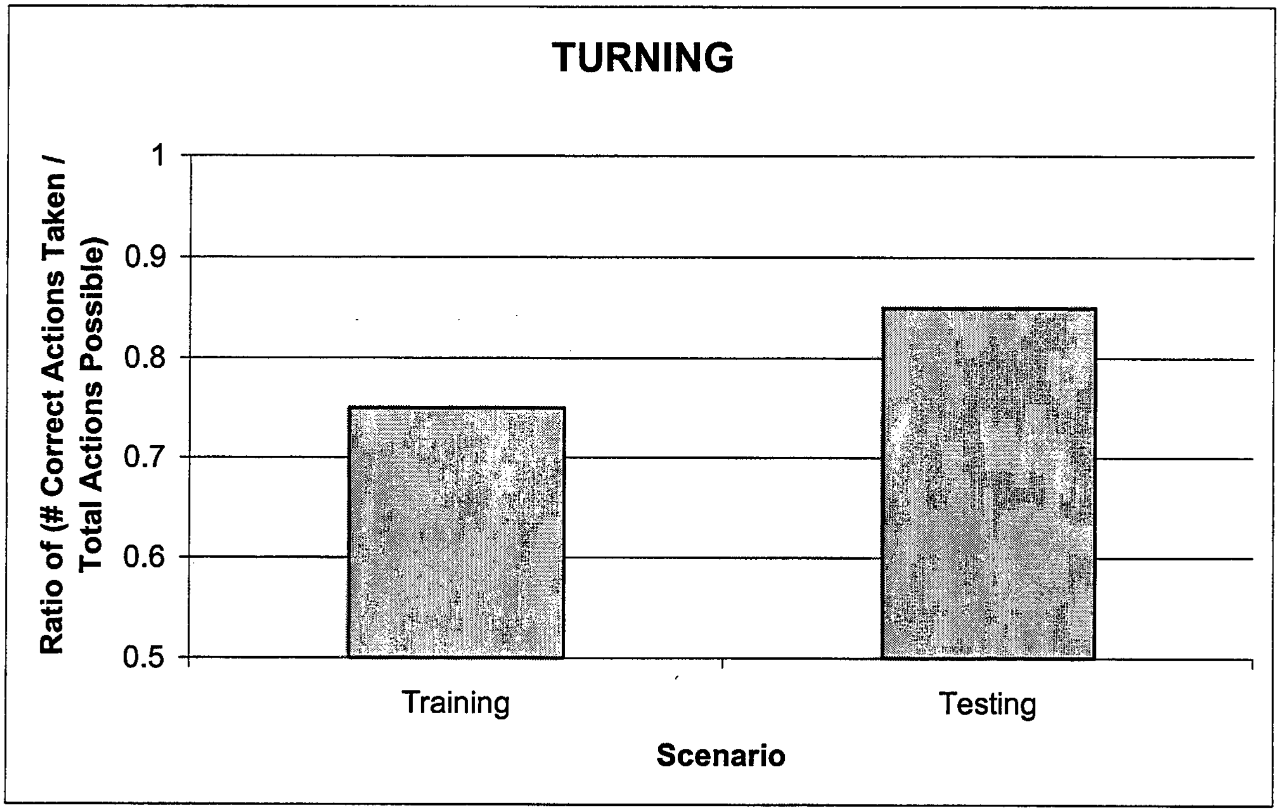

Figure 7:
Trainees' Performance on Turning Commands During the VESUB TEE

No significant main effect was found for the between-subjects factor of experience level, $F(2, 36) = 3.90$, $p = .03$, and no significance was found for the interaction of scenario session and experience level, $F(2, 36) = 1.54$, $p = .228$, indicating that learning was not affected by level of experience and that learning occurred across all levels of experience.

Visually checking the rudder was the ratio of the number of times the trainees physically turned around to visually check the rudder compared with the number of times the trainees should have visually checked the rudder as determined by SMEs. A mixed factorial ANOVA yielded a significant main effect for scenario session, $F(1, 36) = 17.29$, $p = .000$. The mean score on this variable for the training scenario was .54, and for the testing scenario was .72. This indicates that out of 100% of the possible times that the trainees should have physically turned around to visually check the rudder in the training and testing scenarios, the trainees correctly checked the rudder 54% of the time in the training scenario and 72% of the time in the testing scenario. Figure 8 shows a graphic representation of the performance of trainees on visually checking the rudder during the training and testing scenarios.

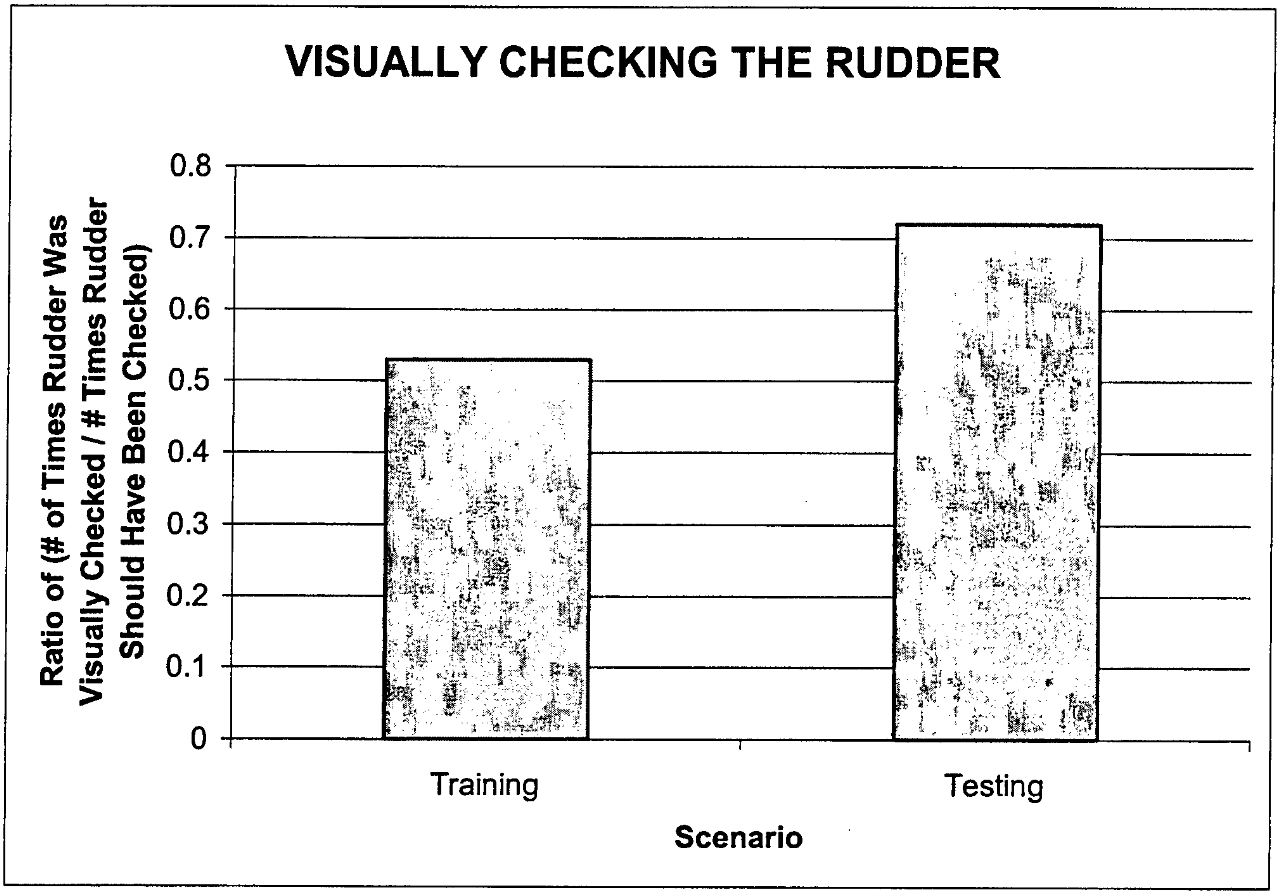

Figure 8:
Trainees' Performance on Visually Checking the Rudder During the VESUB TEE

No significant main effect was found for the between-subjects factor of experience level, $F(2, 36) = .898$, $p = .416$, and no significance was found for the interaction of scenario session and experience level, $F(2, 36) = 2.75$, $p = .077$, indicating that learning was not affected by level of experience and that learning occurred across all levels of experience.

Visually checking ranges was the ratio of the number of times the trainees visually checked the ranges compared with the number of times the trainees should have visually checked the ranges as determined by SMEs. A mixed factorial ANOVA yielded a significant main effect for scenario session, $F(1, 36) = 26.68$, $p = .000$. The mean score on this variable for the training scenario was .54 and for the testing scenario was .75. This indicates that out of 100% of the possible times that the trainees should have visually checked the ranges in the training and testing scenarios, the trainees correctly checked the ranges 54% of the time in the training scenario and 75% of the time in the testing scenario. Figure 9 shows a graphic representation of the performance of trainees on visually checking the ranges during the training and testing scenarios.

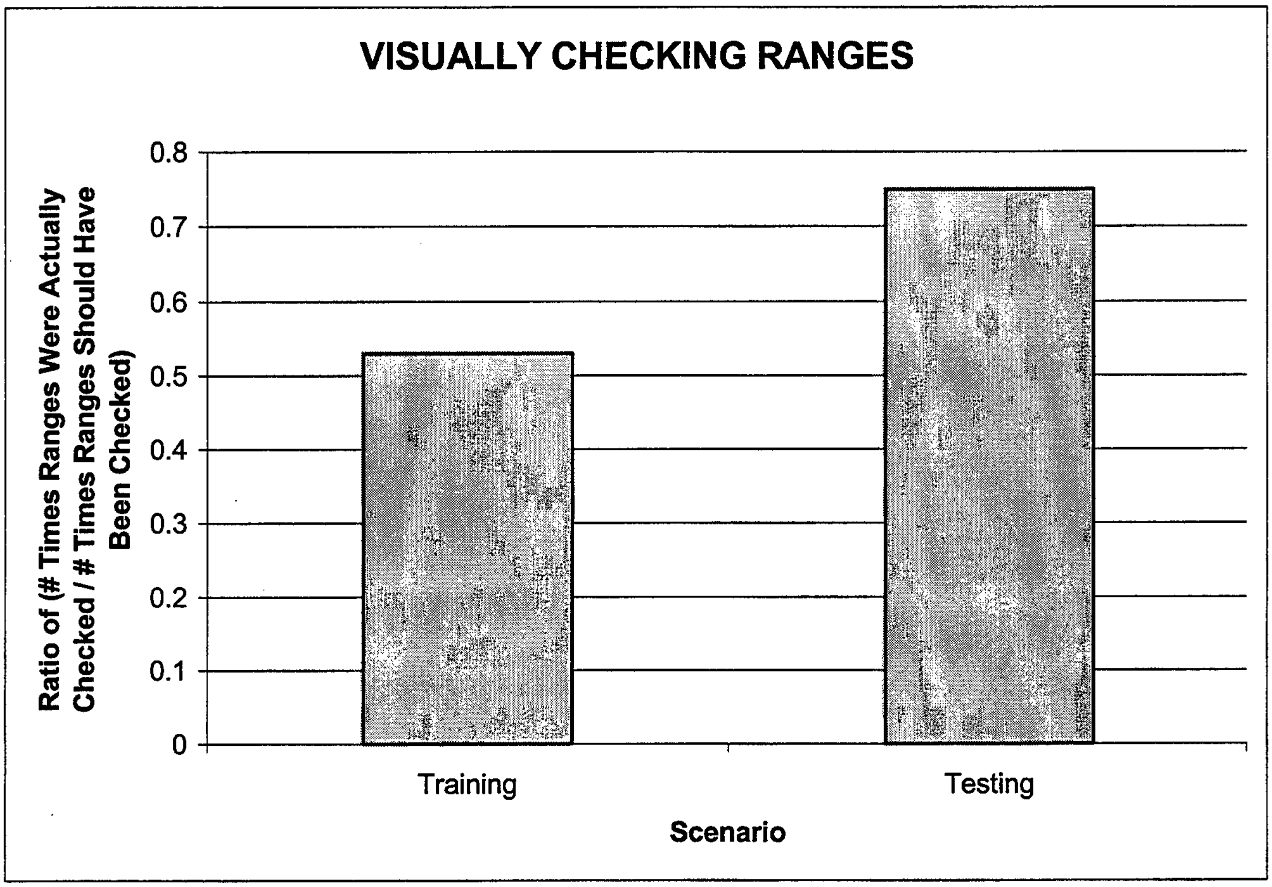

Figure 9:
Trainees' Performance on Visually Checking Ranges During the VESUB TEE

No significant main effect was found for the between-subjects factor of experience level, $F(2, 36) = 1.36$, $p = .271$. A significant effect was found for the interaction of scenario session and experience level, $F(2, 36) = 5.28$, $p = .010$. Figure 10 shows a graphic representation of this interaction.

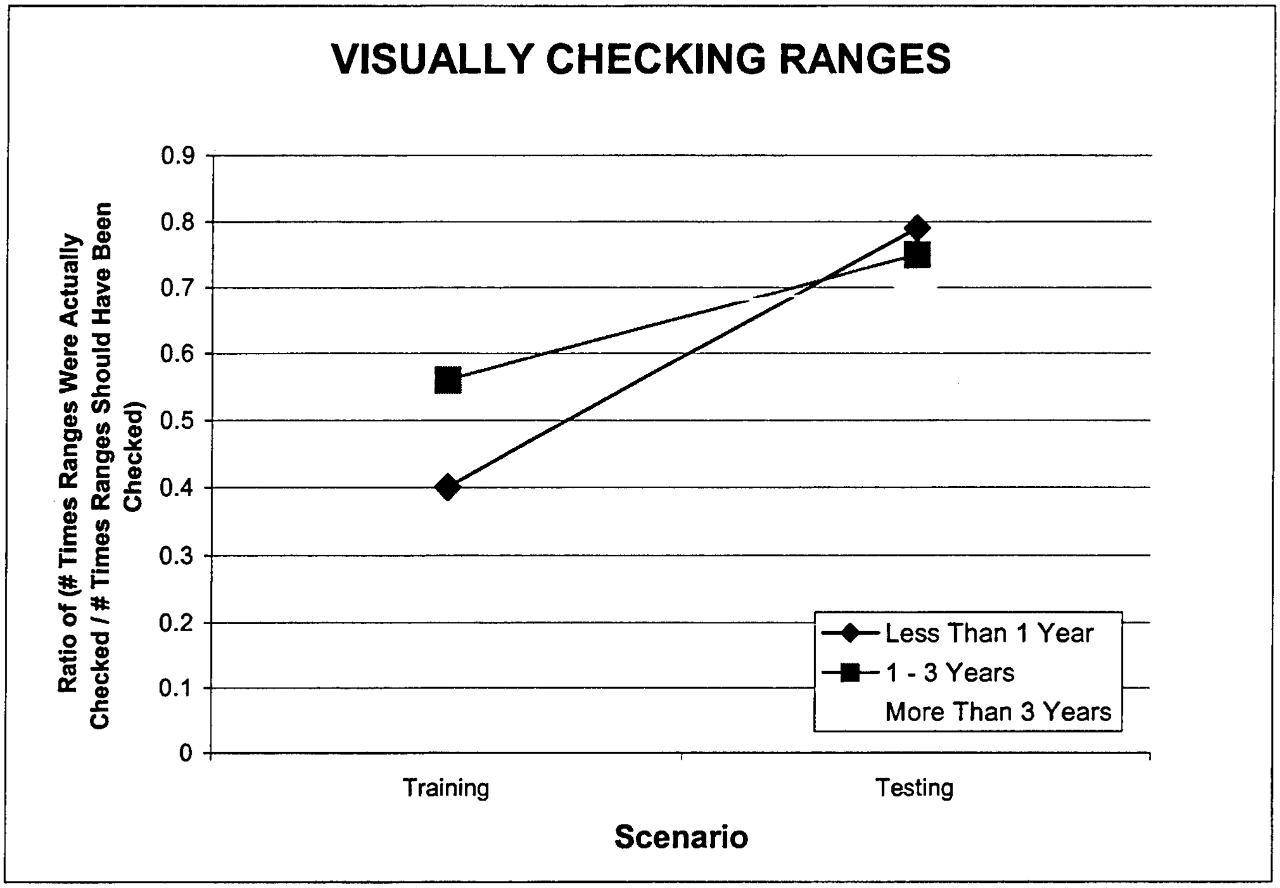

Figure 10:
Interaction of Experience Level and Range Checking Performance During the VESUB TEE

The means for the trainees with "less than 1 year" of ship handling experience were .40 and .79 for the training and testing scenarios respectively. The means for the trainees with "1 to 3 years" of ship handling experience were .56 and .75 for the training and testing scenarios respectively. The means for the trainees with "more than 3 years" of ship handling experience were .65 and .70 for the training and testing scenarios respectively. The greatest amount of improvement occurred in the "less than 1 year" ship handling experience group. The "1 to 3 years" ship handling experience group improved less than the "less than 1 year" group but more than the "more than 3 year" group. The least amount of improvement occurred in the "more than 3 years" ship handling experience group. This does not mean, however, that learning did not occur across all three experience levels. This simply illustrates the point that the most experienced group performed at an initially higher level in the training scenario than the other two groups, and as a result of this initially higher level of performance, improved the least between training and testing.

Emergency Procedures

Three variables were used to assess the trainees learning of appropriate actions to be taken during emergency situations: man overboard reaction time, man overboard commands and yellow sounding. Man overboard reaction time was the time between the occurrence of the man overboard event and the time until the trainee initiated the first correct command and/or took an action associated with proper handling of the emergency event. A mixed factorial ANOVA yielded a significant main effect for scenario session, $F(1, 36) = 17.99$, $p = .000$, indicating that a significant improvement in reaction time occurred. The mean score on this variable for the training scenario was 5.34 seconds, and for the testing scenario was 2.99 seconds. The trainees' overall improvement in terms of time to react to this emergency was 2.35 seconds. Figure 11 shows a graphic representation of the performance of trainees on reaction time during the training and testing scenarios for the man overboard emergency event.

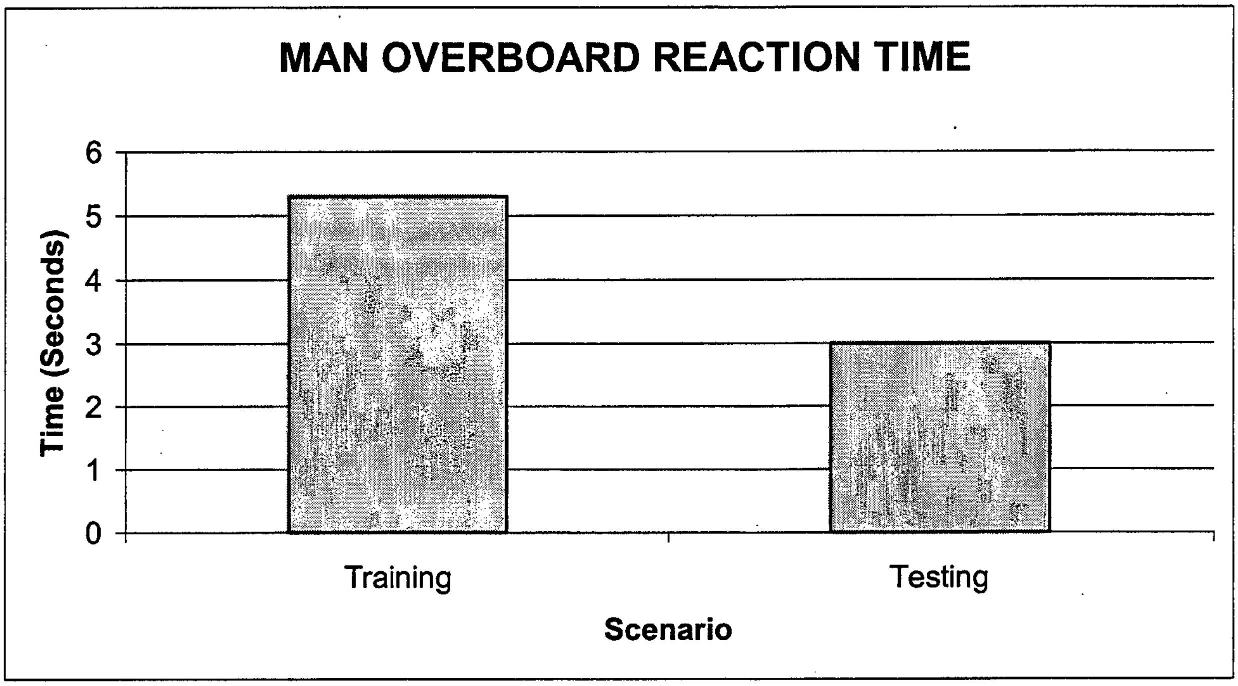

Figure 11:
Trainees' Performance on Man Overboard Reaction Time During the VESUB TEE

No significant main effect was found for the between-subjects factor of experience level, $F(2, 36) = .525$, $p = .596$, and no significance was found for the interaction of scenario session and experience level, $F(2, 36) = .084$, $p = .920$, indicating that learning was not affected by level of experience and that learning occurred across all levels of experience.

Man overboard commands was the number of correct commands issued in response to the man overboard event. A mixed factorial ANOVA yielded a significant main effect for scenario session, $F(1, 36) = 21.96$, $p = .000$, indicating that a significant improvement in the number of correct commands and/or actions taken during the man overboard emergency event had occurred. The mean score on this variable for the training scenario was 3.74 commands issued, and for the testing scenario was 5.25 commands issued. Figure 12 shows a graphic representation of the performance of trainees on number of correct commands and/or actions taken for the man overboard emergency event during the training and testing scenarios.

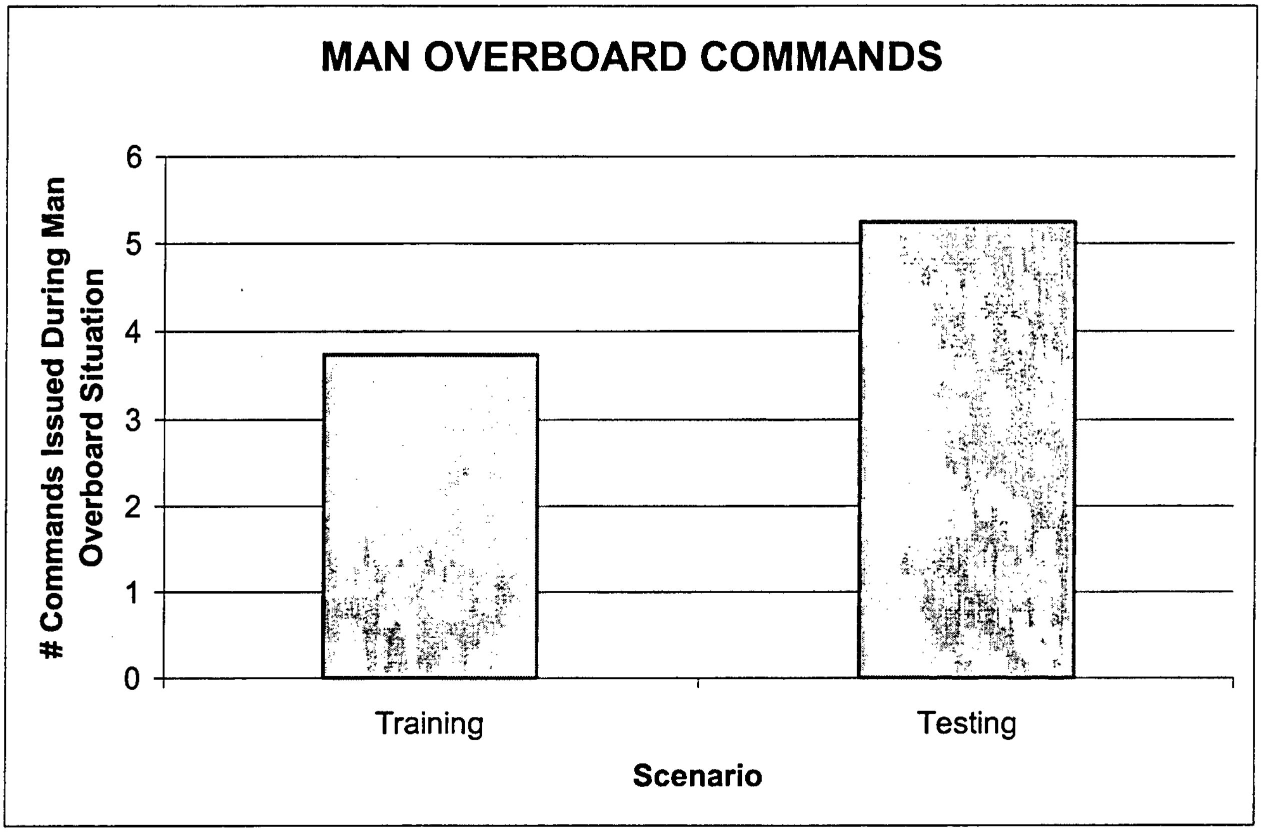

Figure 12:
Trainees' Performance on Man Overboard Commands During the VESUB TEE

No significant main effect was found for the between-subjects factor of experience level, $\underline{F}(2, 36) = .821$, $\underline{p} = .448$, and no significance was found for the interaction of scenario session and experience level, $\underline{F}(2, 36) = 2.21$, $\underline{p} = .125$, indicating that learning was not affected by level of experience and that learning occurred across all levels of experience.

<u>Yellow sounding</u> was the number of correct commands issued in response to a yellow sounding emergency situation. A mixed factorial ANOVA yielded a significant main effect for scenario session, $\underline{F}(1, 36) = 14.76$, $\underline{p} = .000$, indicating that a significant improvement in the number of correct commands and/or actions taken during the yellow sounding emergency event had occurred. The mean score on this variable for the training scenario was 3.74 commands issued, and for the testing scenario was 5.25 commands issued. Figure 13 shows a graphic representation of the performance of trainees on handling of the yellow sounding emergency event during the training and testing scenarios.

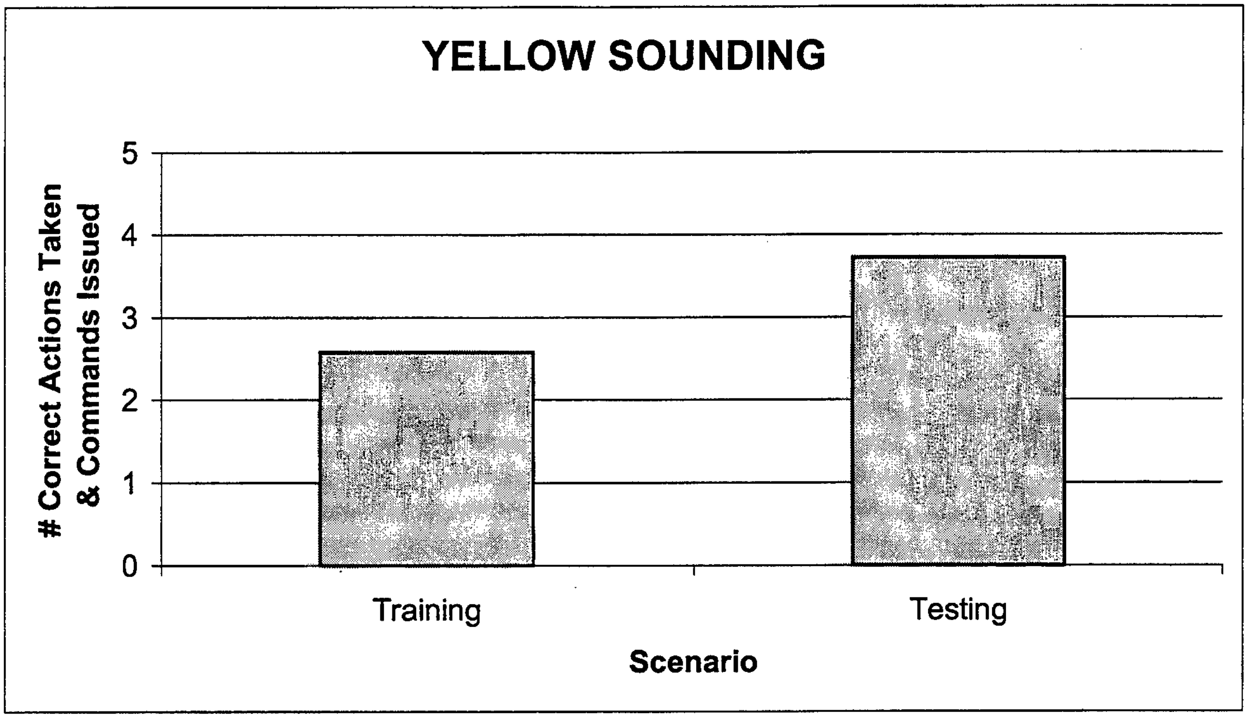

Figure 13:
Trainees' Performance on Yellow Sounding Actions and Commands During the VESUB TEE

No significant main effect was found for the between-subjects factor of experience level, $\underline{F}(2, 36) = 1.96$, $\underline{p} = .155$, and no significance was found for the interaction of scenario session and experience level, $\underline{F}(2, 36) = .352$, $\underline{p} = .706$, indicating that learning was not affected by level of experience and that learning occurred across all levels of experience.

Incorrect Report Recognition

Incorrect Position Determination was the number of correct commands issued or actions taken in response to an incorrect position reported by own ship's navigator. Examples of correct actions include: checking ranges or other navigation aids, asking for a repeat of the navigator's report, or disagreeing with the report. A mixed factorial ANOVA yielded a significant main effect for scenario session, $\underline{F}(1, 36) = 7.08$, $\underline{p} = .01$, indicating that a significant improvement in the number of correct commands issued and/or actions taken during the incorrect position event had occurred. The mean score on this variable for the training scenario was .81 commands issued and/or actions taken, and for the testing scenario was 1.53 commands issued and/or actions taken. Figure 14 shows a graphic representation of the performance of trainees on handling of the incorrect report recognition event during the training and testing scenarios.

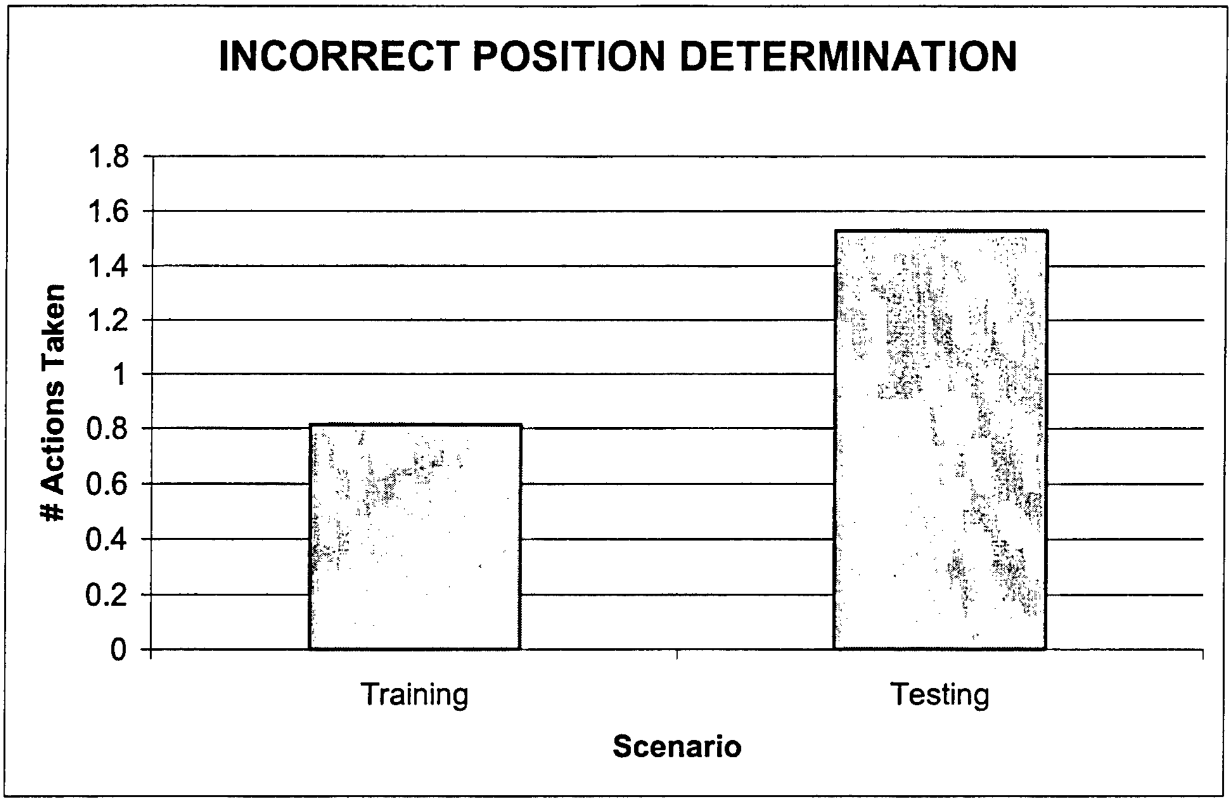

Figure 14:
Trainees' Performance on Incorrect Report Recognition During the VESUB TEE

No significant main effect was found for the between-subjects factor of experience level, $\underline{F}(2, 36) = 2.17$, $\underline{p} = .129$, and no significance was found for the interaction of scenario session and experience level, $\underline{F}(2, 36) = .429$, $\underline{p} = .654$, indicating that learning was not affected by level of experience and that learning occurred across all levels of experience.

<u>Communications</u>

Three variables were used to assess the trainees learning of appropriate communication skills: commands to get underway, acknowledging reports, and use of station identifiers. <u>Commands to get underway</u> was the total number of commands correctly issued to properly get own ship underway during the entire scenario. During each scenario there were three instances where the trainee would have needed to issue commands to get own ship underway. A mixed factorial ANOVA did not result in a significant main effect for scenario session, $\underline{F}(1, 36) = 4.48$, $\underline{p} = .041$, indicating that no significant improvement in the number of commands issued to get own ship underway occurred between the training and testing scenarios. A significant main effect was found for the between-subjects factor of experience level, $\underline{F}(2, 36) = 5.43$, $\underline{p} = .009$, indicating that prior experience in ship handling did have an affect on learning effectiveness in this particular task. Figure 15 shows a graphic representation of the performance of trainees on execution of proper commands issued to get own ship underway during the training and testing scenarios.

From looking at the graph of the means we can see that the "less than 1 year" and "1 to 3 years" experience groups both performed significantly better in the training scenario than the "more than 3 years" group. Although the "less than 1 year" and the "1 to 3 years" groups both improved in the testing scenarios, this improvement was not significant.

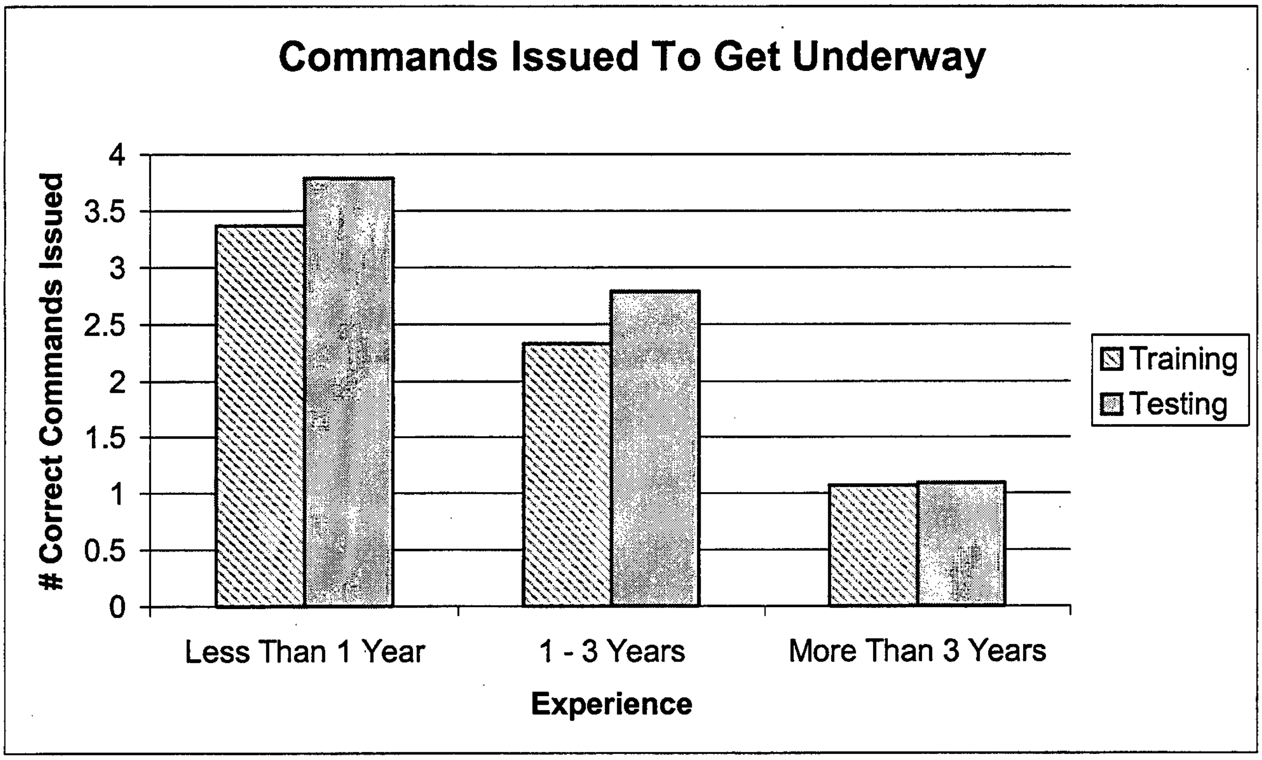

Figure 15:
Trainees' Performance on Commands to Get Underway During the VESUB TEE

No significance was found for the interaction of scenario session and experience level, $F(2, 36) = .838$, $p = .441$.

Acknowledging reports was a ratio of the number of times reports were received by the trainee and were correctly acknowledged compared to the total number of reports received by the trainee. A mixed factorial ANOVA did not result in a significant main effect for scenario session, $F(1, 36) = .512$, $p = .479$, indicating that no significant improvement in the number of reports acknowledged occurred between the training and testing scenarios (training scenario mean = .73 and testing scenario mean = .76). No significant main effect was found for the between-subjects factor of experience level, $F(2, 36) = 1.76$, $p = .186$. No significant interaction between scenario session and experience level occurred $F(2, 36) = 2.61$, $p = .088$.

Use of station identifiers was recorded as the number of times station identifiers were not used correctly. A mixed factorial ANOVA resulted in a significant main effect for scenario session, $F(1, 36) = 42.42$, $p = .000$, indicating that a significant improvement in the use of station identifiers did occur between the training and testing scenarios. The mean score on this variable for the training scenario was 1.39 times stations identifiers were not used correctly, and for the testing scenario was .57 times station identifiers were not used correctly. Figure 16 shows a graphic representation of the performance of trainees on issuance of proper station identifiers during the training and testing scenarios.

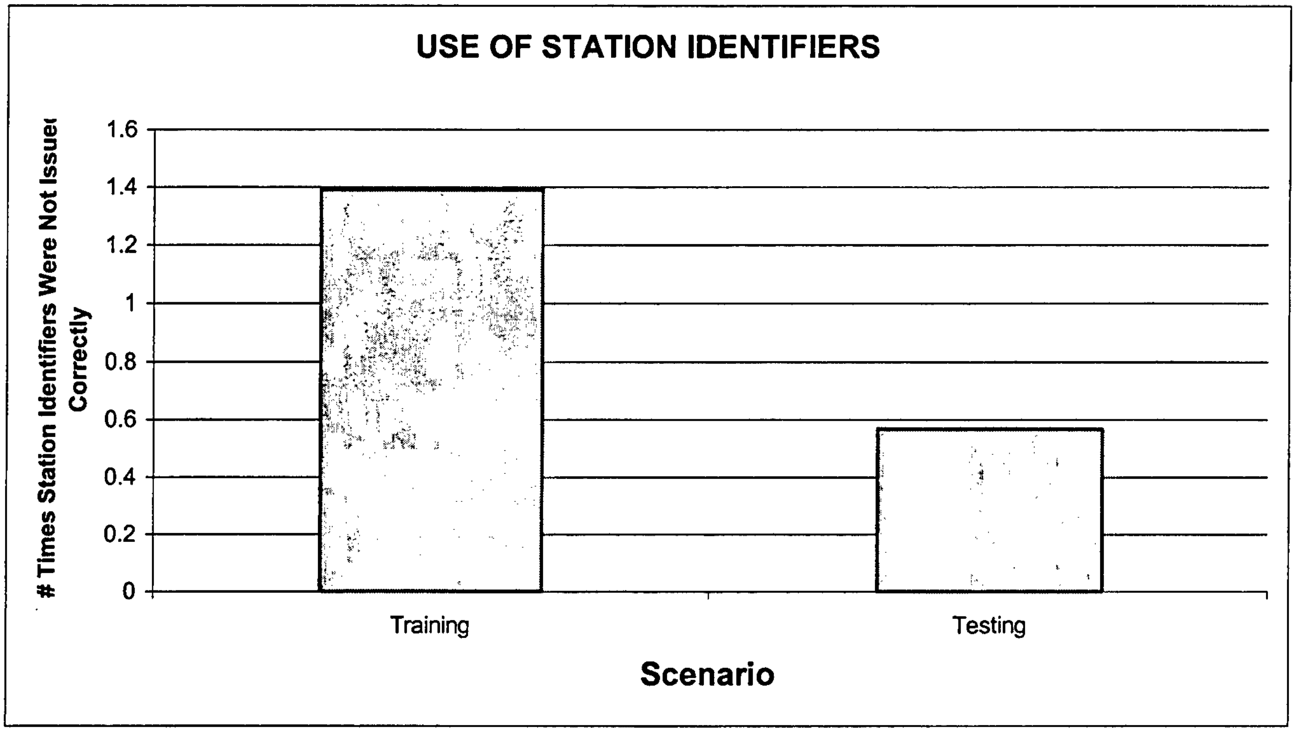

Figure 16:
Trainees' Use of Station Identifiers During the VESUB TEE

No significant main effect was found for the between-subjects factor of experience level, $\underline{F}(2, 36) = 1.29$, $\underline{p} = .286$ and no significant interaction between scenario session and experience level occurred $\underline{F}(2, 36) = .309$, $\underline{p} = .736$.

Rules of the Road

One variable was used to assess the trainees' learning and comprehension of rules of the road: ferry passage. Ferry Passage was the total number of commands correctly issued to properly and safely execute a port-to-port passage with an approaching traffic vessel that had crossed from right to left. A mixed factorial ANOVA resulted in a significant main effect for scenario session, $\underline{F}(1, 36) = 42.42$, $\underline{p} = .000$, indicating that a significant improvement in the number of commands issued to safely execute a port-to-port passage with other traffic vessels occurred between the training and testing scenarios. The mean score on this variable for the training scenario was 2.88 commands issued, and for the testing scenario was 4.43 commands issued. Figure 17 shows a graphic representation of the performance of trainees on execution of proper commands.

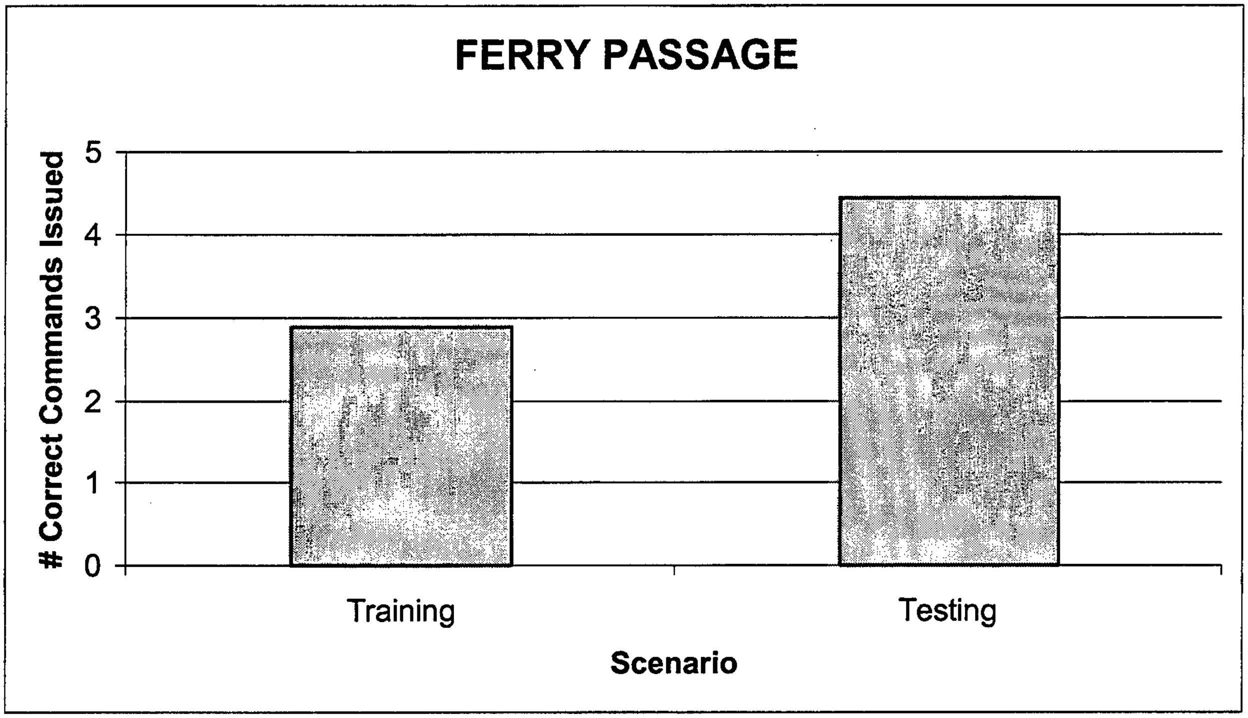

Figure 17:
Trainees' Performance on Rules of the Road Skills During the VESUB TEE

No significant main effect was found for the between-subjects factor of experience level, $\underline{F}(2, 36) = .522$, $\underline{p} = .598$ and no significant interaction between scenario session and experience level occurred $\underline{F}(2, 36) = .205$, $\underline{p} = .815$.

EXPERT OPINION DATA

Opinions on the VESUB system were solicited from the trainees after they experienced the orientation, training, and testing scenarios. Additional expert opinions were collected from eleven persons who were not part of the formal TEE, but who experienced demonstration scenarios and observed portions of the TEE (a twelfth observer only provided open-ended comments).

Trainees' Opinions

At the end of the TEE, each trainee was given an opinion questionnaire to fill out (Appendix G). The questionnaire consisted of a series of eight forced-choice questions and one open-ended question. Six questions referred to the training capability and functionality of the VESUB system and two questions concerned the comfort and functionality of the HMD. The forced-choice questions were answered by circling the appropriate answer on a Likert Scale with the choices being "strongly agree," "agree," "neutral," "disagree," and "strongly disagree."

1. Positive Learning Experience. The majority of the trainees reacted very positively to the VESUB system. For question One, "I had a positive learning experience in the VESUB system," 28 out of 42 trainees (66.7%) responded that they "strongly agreed," 13 out of 42 (31.0%) responded that they "agreed" and 1 out of 42 (2.3%) responded that they were "neutral." None of the trainees responded that they "disagreed" or "strongly disagreed" which would have indicated that they did not have a positive learning experience with the VESUB system.

2. Increased Confidence. For question Two, "Training with VESUB will increase my confidence in my ship handling skills," 27 out of 42 (64.3%) responded that they "strongly agreed," 12 out of 42 (28.6%) responded that they "agreed," and 2 out of 42 (4.8%) responded that they were "neutral." Only 1 out of 42 (2.3%) responded that they "disagreed" and none responded that they "strongly disagreed," indicating that over 97% of the trainees that participated left with increased confidence in their ship handling skills.

5. Introductory Training. On question Five, "VESUB should be used for introductory ship handling training," 34 out of 42 (81.0%) responded that they "strongly agreed," 7 out of 42 (16.7%) responded that they "agreed," and 0 out of 42 (0.0%) responded that they were "neutral." Only 1 out of 42 (2.3%) responded that they "disagreed" and none responded that they "strongly disagreed," indicating that over 97% of the trainees that participated indicated that they felt that VESUB would be an excellent tool for introductory ship handling training.

6. Refresher Training. On question Six, "VESUB should be used for refresher training for ship handling skills," 30 out of 42 (71.4%) responded that they "strongly agreed," 9 out of 42 (21.4%) responded that they "agreed," and 3 out of 42 (7.2%) responded that they were "neutral." None responded that they "disagreed" or that they "strongly disagreed," indicating that 93% of the trainees that participated felt that VESUB would be an excellent tool for refresher ship handling training.

7. Classroom Only. On question Seven, "VESUB should only be used in the classroom (shore based) training," 5 out of 42 (12.0%) responded that they "strongly agreed," 8 out of 42 (19.0%) responded that they "agreed," 8 out of 42 (19.0%) responded that they were "neutral," 13 out of 42 (31.0%) responded that they "disagreed," and 8 out of 42 (19.0%) responded that they "strongly disagreed." These results show that the trainees had very mixed opinions about using VESUB exclusively for classroom training.

8. Mission Rehearsal. Question Eight stated, "VESUB should be installed on submarines for mission rehearsal and refresher training." Ten out of 42 (23.8%) responded that they "strongly agreed," 13 out of 42 (31.0%) responded that they "agreed," 15 out of 42 (35.7%) responded that they were "neutral," 3 out of 42 (7.1%) responded that they "disagreed," and 1 out of 42 (2.3%) responded that they "strongly disagreed." These results indicate that although most trainees believe VESUB could be used for mission rehearsal, some are still skeptical.

Figure 18 shows a graphical representation of the frequencies of responses for the previous six questions.

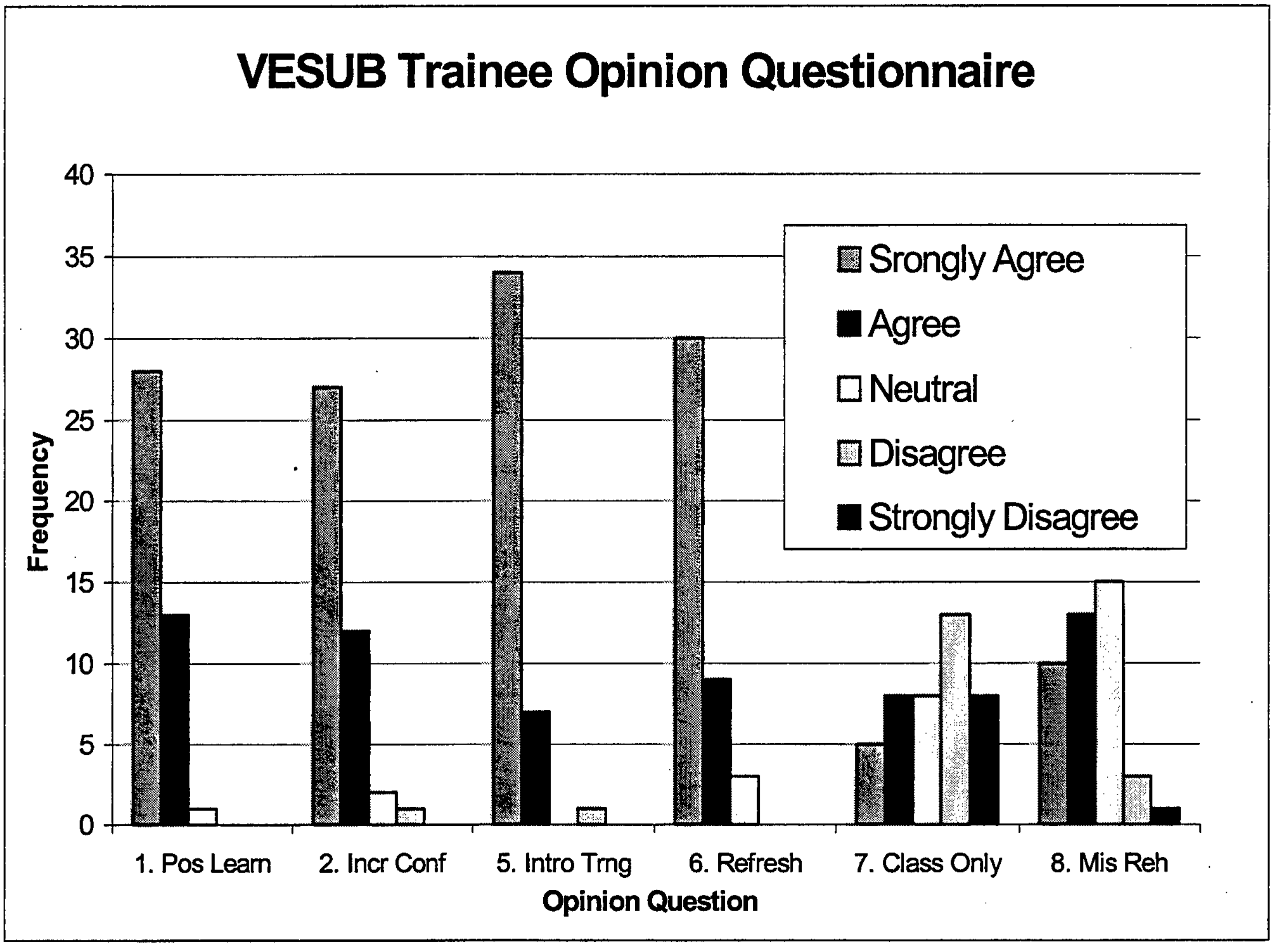

Figure 18:
TEE Trainees' Opinions on the VESUB System

The remaining two questions dealt not with the training effectiveness and functionality of the system, but with the comfort and functionality of the HMD which indirectly may have affected the training effectiveness and functionality of the VESUB training system as a whole.

3. HMD Visual Adjustment. On question Three, "I was able to fully adjust the VESUB HMD to meet my specific visual need," 14 out of 42 (33.3%) responded that they "strongly agreed," 17 out of 42 (40.5%) responded that they "agreed," 6 out of 42 (14.3%) responded that they were "neutral," and 5 out of 42 (12.0%) responded that they "disagreed." None responded that they "strongly disagreed."

4. HMD Fit Adjustment. On question Four, "I was able to fully adjust the VESUB HMD comfortably to fit my head," 10 out of 42 (23.8%) responded that they "strongly agreed," 17 out of 42 (40.5%) responded that they "agreed," 11 out of 42 (26.2%) responded that they were "neutral," and 4 out of 42 (9.5%) responded that they "disagreed." None responded that they "strongly disagreed."

Open-Ended Question. The open-ended question allowed the trainees to provide comments and suggestions on any topic that they believed would improve the performance or training effectiveness of VESUB. Below is a listing of their comments grouped into content areas. The number in parentheses following some comments indicates multiple instances of similar comments.

General Reactions to System

- I learned or relearned several lessons today.
- Overall, a very good system. Provides realistic training in an environment where mistakes don't cost a crew or a boat (2).
- A very good product. Great tool. Outstanding system (4).
- Provides a strong tool for improving ship handling and contact management for OODs.
- Training is very effective and comfortable.
- Excellent training experience (2).
- I felt off balance. We have a seat on the port side of the bridge.

Instructional Tools or Approaches

- Setting up situations where the Navigator makes incorrect recommendations is a good idea (e.g., mark turn when it should be later to avoid a contact; come left when should be right).
- It helped a lot to be able to practice casualties and commands.

Voice and Sounds

- Unable to give commands while system is speaking. OOD should override all voices, waiting for system to finish wastes valuable time. Sometimes unable to get a word in edgewise. Frustrating (15).
- Speech recognition/synthesis needs to be faster (3).
- Expand vocabulary (e.g., "continue right…,")
- Include cardinal headings for Helm.
- Need to be able to correct spoken errors (e.g., "[incorrect command], correction, [new command]")
- Include virtual Contact Coordinator.
- Eliminate station identifiers.
- Reduce redundant repeat backs.
- Speech recognition is excellent, but some ships may have different standing orders. More flexibility (3).
- Need to be able to give multiple commands to different stations simultaneously. Need to re-key the mike is unrealistic (3).
- Improve wind noise as a speed cue.
- Add more sounds. They make it seem more realistic (e.g., passing boats on one side or the other).

Visual Scene and Visual System

- Include a switch to activate/deactivate binoculars rather than a voice command to speed up and reduce confusion (13).
- Objects at a distance need to have higher resolution to reduce need for binoculars.
- Ambiguity in contact visual range and AOB is good – keep it.
- Visual scene was a bit jittery when doing a visual scan – increase refresh rate (3).
- Simulate a grease pencil to check off courses on the course card and record contacts (2).
- Chart should be more realistic – include shoal water and soundings.
- Chart not marked up the way they normally are. Too much information and difficult to find navigation aids (3).
- Implement virtual body/feet to increase realism (2).
- Place Pilot, CAPT, etc. in cockpit to increase realism.
- Improve bow wave as a speed cue.
- Adjust wake to a more realistic size.
- Add more contacts.
- Visual contrast is poor – objects which are readily detectable in real life require binoculars in the virtual world.
- No real sense of distance and poor spacial awareness.
- Include a time display (for 3 minute rule).

Submarine Model

- Sub seems to respond too fast to bell orders.

Use of the System

- Great introductory training for OODs.
- Would welcome the opportunity to train JOs all the way up to COs (from SOBC throughout career). VESUB would be effective for introductory and refresher training (6).
- Recommend that all ANAVS and members of the Navigation Team train on VESUB to enhance their skills (2).
- Combine with other trainers for full control party training.
- Valuable onboard for mission rehearsal in/out of unfamiliar ports.
- Great to teach JOs how to moor a ship – something we have little chance to do.
- System would provide extremely good training with an experienced training team.
- Setting up collision scenarios (e.g., Jacksonville) and giving poor recommendations from the Navigator would be excellent training.
- You could replay COMSUBLANT Lessons Learned (collision/grounding presentations) to show where mistakes were made.
- Make VESUB a requirement (similar to a fast cruise) for boats that have been in port for a prescribed number of days.
- Must reduce size of system if it is to be brought aboard the ship.
- Could be useful for at-sea training.
- Sub-based system would be great for prepiloting training and proficiency training during long underway time.

- Use of VESUB to practice open-ocean MOBs could be useful to practice recovery by own ship.
- Add additional scenarios (e.g., jammed rudder, open ocean with other contacts).

Head-Mounted Display
- HMD is uncomfortable after a while – consider more padding on the top piece (2).
- A wider field of view would help. Had to move head more than in real life (7).
- Felt fatigue in shoulders and upper back from holding HMD.
- Make large enough to fit while wearing glasses.
- Fit pretty well but shifted when I looked over the side.
- Too much stray light in at the bottom.
- HMD cord sometimes got tangled with my feet – perhaps suspend the cord off of the deck.
- HMD might benefit from a chin strap.
- The rear adjustment popped open each time I tried to tighten it.
- Problems fitting HMD properly.
- HMD focus was in a position that I bumped it each time I tried to hold HMD steady.

Haptic Capabilities
- Implement virtual hands to assist OOD (2).

Observers' Opinions

Observers of the TEE filled out the Observer Questionnaire (Appendix H), which consisted of six forced-choice questions and one open-ended question. The forced-choice questions were a variation of the questions answered by the trainees, but without reference to HMD fit and adjustments. Figure 19 is a graphical representation of the responses to the observer questions.

1. Positive Learning. Question One stated, "The VESUB system provides a positive learning experience." As can be seen in Figure 19, all of the observers either "agreed" (3 of 11; 27%) or "strongly agreed" with this statement (8 of 11; 73%).

2. Increased Confidence. On question Two, "Training with VESUB will increase a trainee's confidence in his ship handling skills," 5 out of 11 (45.5%) "strongly agreed," 5 (45.5%) "agreed," and 1 (9%) was "neutral."

3. Introductory Training. On question Three, "VESUB should be used for introductory ship handling training," 6 out of 11 (54.5%) "strongly agreed," 3 (27%) "agreed," and 2 (18%) were "neutral."

4. Refresher Training. Question four stated, "VESUB should be used for refresher training for ship handling skills." With the exception of one neutral observer (9%), everyone either strongly agreed (54.5%) or agreed (4 of 11; 36%).

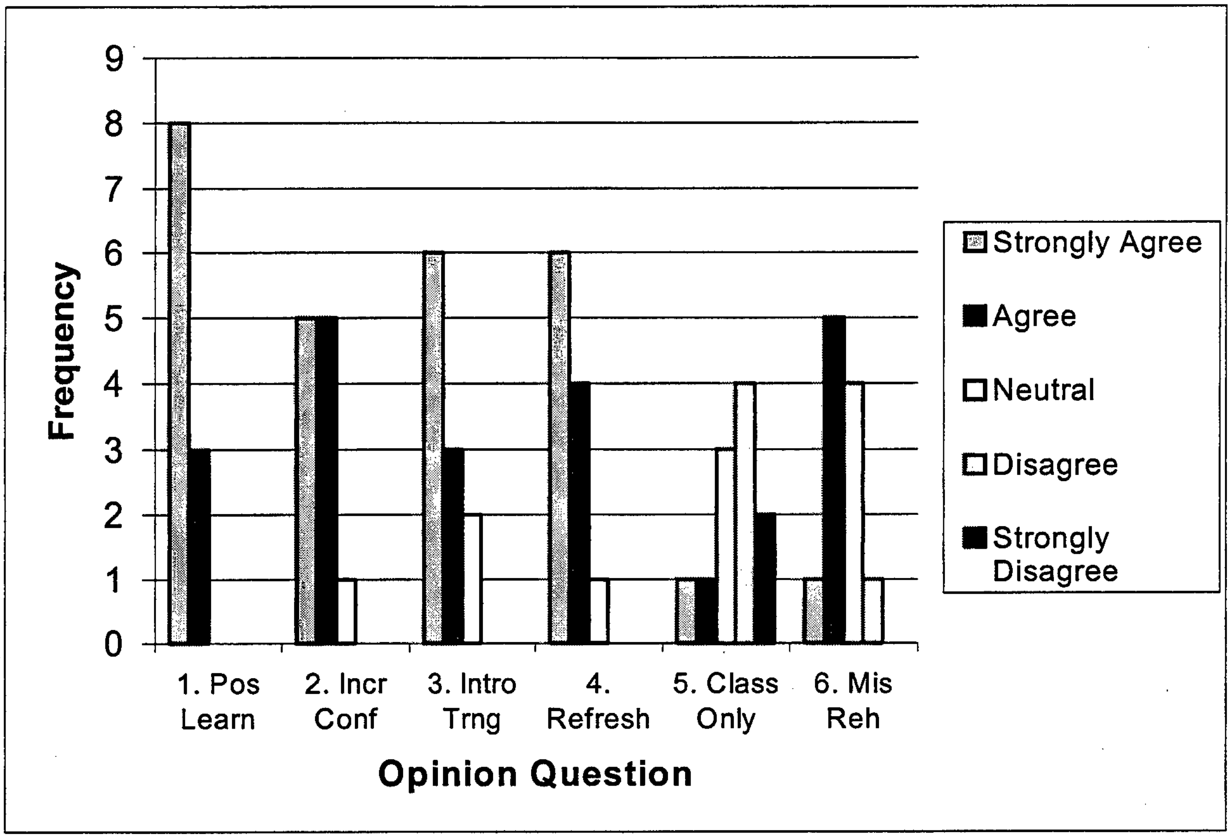

Figure 19:
TEE Observers' Opinions on the VESUB System

<u>**5. Classroom Only**</u>. On question Five, "VESUB should only be used in classroom (shore-based training)," 1 of 11 (9%) "strongly agreed," 1 (9%) "agreed," 3 (27%) were "neutral," 4 (36%) "disagreed," and 2 (18%) "strongly disagreed."

<u>**6. Mission Rehearsal**</u>. The sixth and final forced-choice question stated, "VESUB should be installed on submarines for mission rehearsal." Most observers either "agreed" (5; 45.5%) or were "neutral" (4; 36%) on this question. One person (9%) "strongly agreed" and 1 (9%) "disagreed."

<u>**Open-Ended Question**</u>. The open-ended question allowed the observers to discuss any topic they believed would improve VESUB. Below is a listing of their comments, broken into content areas.

<u>General Reactions to System</u>

- This trainer has excellent potential.
- This is an excellent system.

System Expansions
- Provide an open ocean scenario database.
- Mooring and docking would be a GREAT benefit.
- Integration into various teams (maneuvering watch, piloting) is an area with value.
- Use for maintenance training (e.g., torpedo handling).

Instructional Tools
- Use red to highlight red buoy edge of channel, green for green buoy edge.

Voice and Sounds
- Improve background sounds, both from environment and ship.
- Verbal interface needs work. Student can't be heard while the system is speaking.
- Include more non-universal orders.
- Faster order input or more variable.
- Drop "helm-bridge" from voice commands.
- Voice of Nav/Helm is choppy, separate words from numbers.
- Navigator courses are difficult to understand. Pause before the course.
- Binocular command should be manual.

Visual Scene and Visual System
- Include area for OOD to write down data (grease pencil on windshield).
- Field of view in HMD needs to be wider.
- A bridge-to-bridge radio is needed.
- Radar Repeater, GPS, Etc. would be effective.
- Contact card for bridge-to-bridge communications.
- Visual clarity of objects diminishes with range faster than real life.
- Improve refresh rate of visuals when trainee's head moves.

Virtual Crew
- Include Contact Coordinator in virtual crew.

Addition of Haptic Capabilities
- Make the alidade more interactive.
- Bring the subject's hands into play.
- Include use of a single VR glove.

DISCUSSION

SIMULATION SIDE EFFECTS

The use of virtual environments for future training systems will depend not only on the implementation for specific tasks, but also on whether trainees can learn in the virtual environment. Learning can not occur if the trainee's interface with the virtual world causes side effects that distract the trainee. The VESUB TEE was one of the most extensive evaluations of a virtual environment training system yet to be conducted. Each trainee experienced three scenarios in the virtual environment for a total of almost 2 hours. It was also one of the first to be conducted in a training facility with Navy trainees and operational personnel rather than a laboratory with college students. The extent of simulation side effects during this TEE could influence the use of VE for other applications.

Of the 41 subjects who participated in the TEE, two experienced symptoms that were severe enough that they requested to be removed from the system. Data collectors, monitoring the subjects' physical conditions, had prompted the subjects to request removal from the system. Both subjects were from the Norfolk subject pool (N-7 and N-14). Subject N-7 was removed after 10 minutes and 10 seconds of the training scenario. Subject N-14 lasted for twenty-three minutes and fifteen seconds of the training scenario. Subject N-7 reported moderate levels of general discomfort, sweating, and stomach awareness, and a severe level of increased salivation. Subject N-14 reported moderate levels of headache, and slight levels of general discomfort, eye strain, difficulty focusing, difficulty concentrating, stomach awareness, and burping. Both subjects reported moderate levels of Nausea.

One additional subject asked to be removed from the system after only about two minutes of the orientation scenario and was immediately replaced. An interview with this subject revealed that he is very sensitive to viewing any computer screen. He reported that he becomes dizzy when watching his son play video games. He was, therefore, considered an anomaly and his scores were not included in the side effects data.

Often, researchers using the Simulator Sickness Questionnaire (SSQ) use the preexposure data as a screening mechanism to eliminate persons who arrive at the simulator with some preexisting condition (Kennedy, et al., 1993). For the purposes of this report, the preexposure data are included and no subjects were eliminated from further analyses. Persons who wish to take a more conservative approach may use the raw data found in Appendix K.

The frequency of the Total SSQ scores are shown in Table 2 and Figure 2. Over half of the participants showed zero or low (11.22 and below) Total SSQ scores on the pretest and after each scenario. Most other scores fall in the moderate range (14.96 – 37.4). Although the frequency of higher Total SSQ scores increases after the scenarios, only two cases of very high scores were reported. These were during the training scenario from the two individuals who were removed from the system. Most individuals had no trouble staying in the system for the entire TEE and experienced only low to moderate side effects.

The mean subfactor scores are shown in Figure 3. All subfactors increase after the scenarios. The Nausea subfactor is relatively low after the orientation, but increases after the training scenario. This is because the data from the two subjects who were removed during the training scenario inflate these scores. After the testing scenario (without these two subjects), the Nausea subfactor score falls to slightly below the level after the orientation scenario. It appears that, with the exception of highly sensitive persons, nausea does not present a problem in VESUB.

The Oculomotor subfactor scores follow a similar pattern. Although they do not drop as low as the Nausea scores, the mean oculomotor score after the testing scenario is lower than after the training scenario, having dropped almost to the same level as after the orientation scenario. Although not something to ignore, it is likely that improvements in HMD design will lead to fewer oculomotor problems in VE systems.

The Disorientation subfactor scores are also higher after the training scenario, but fall to a lower level after the testing scenario than their level after the orientation scenario. This may be due to subjects becoming more familiar with the narrow field of view in the HMD. By learning to use more head movements and also becoming more familiar with the use of navigation aids, subjects probably experienced less disorientation. Nevertheless, it is expected that HMDs with wider fields of view (both horizontally and vertically) will lead to improvements in this area. Reductions in the number and size of head movements could also lead to improvements in the oculomotor and nausea areas.

Even though individuals were exposed to a VE for a total time of almost two hours, the incidence of simulation side effects during the VESUB TEE was low to moderate. From these data, there is no reason to assume that VEs will produce simulation side effects at a greater rate than any other form of simulation. Furthermore, with longer exposure, individuals appear to acclimate to the system. Improvements in hardware and software should reduce these side effects even more. One possible side effects problem may occur if VE systems are deployed on ships at sea due to asynchrony between ship motion and apparent motion in the VE. However, since most deployed training will be done while the ship is in port (i.e., moored at a pier), VE systems should still be a viable training alternative.

SHIP HANDLING PERFORMANCE

Ship handling is a very complex task, requiring the development of a comprehensive mental model of the task situation and the application of numerous skills supported by various combinations of the perceptual and cognitive components of "Seaman's Eye" (see Table 1). The improvement of trainees' ship handling performance during the TEE was measured on fifteen variables (see Table 3), grouped into seven performance categories. Each of the performance variables used in the TEE required unique combinations of the perceptual and cognitive skills. The most relevant supporting components for successful performance on each variable are used to focus the discussions that follow, along with less detailed discussions of other supporting components.

Measurement on some variables were simple numbers (e.g., time to issue a command or the difference between reported and actual positions). Other variables were measured using ratios (e.g., number of correct actions taken to number of possible correct actions). Ratios were used to account for minor differences between inbound and outbound scenarios (e.g., number of contacts available, number of turns required, etc.). Finally, performance on some variables were rated as satisfactory or unsatisfactory when more than one "correct" answer was possible (e.g., reported position could be distance from the next turn, distance from a navigation aid, distance from a buoy, etc.).

Position Determination

Determination of the position of own ship is a task that must be accomplished each time the OOD assumes the watch. Further actions during the watch will all depend on the accuracy of the OOD's estimation of the current and anticipated location of own ship. There are a variety of navigation aids and geographic features that can be used by the OOD to determine position. The specific navigation aids and geographic features used were recorded by the research team as each trainee made his determination of position. Then, guidance to improve the use of the navigation aids was provided during the instructional intervention segments of the training scenario. Two variables were used to assess improvements in trainees' performance in this skill area: position of own ship across the track and position of own ship along the track.

Position of Own Ship Across Track. This variable measured the trainee's skills in determining the ship's position left or right of the center of the channel. This required the trainee to visually sight the range markers either forward or astern and use them in conjunction with other navigation aids and charts to make this judgment. The measurement was the difference between the trainee's reported distance and actual distance from track.

When using range markers to determine own ship location across the track, orientation can be tricky. Figure 20 helps clarify this procedure. When viewing range markers ahead, if the front marker is to the left of the rear marker, then own ship is right of range and right of track. When viewing range markers astern, if the front marker is to the right of the rear marker, then own ship would be to the left of range, but to the right of track. The distance left or right of track can be determined relatively easily. Knowing the width of the channel (e.g., from the scale on the chart) one knows the maximum distance own ship could be from the centerline. Combining this knowledge with distances from buoys and navigation aids nearby, allows the OOD to fine tune his estimate of distance from the center of the channel. Monitoring of own ship's wake can also give the OOD a general indication of his location in relation to the centerline and navigation aids.

Two perceptual components and one cognitive component of "Seaman's Eye" are most relevant to this task. Components 1P (Locating and Identifying Navigation Aids) and 2P (Judging Distance) require the trainee to survey the visual scene to find and evaluate the available navigation aids. The OOD must determine which of a variety of range markers are the markers for the leg of the channel he is currently on before he can be sure that he is making the correct interpretation from their alignment. To further specify location, the OOD must use component

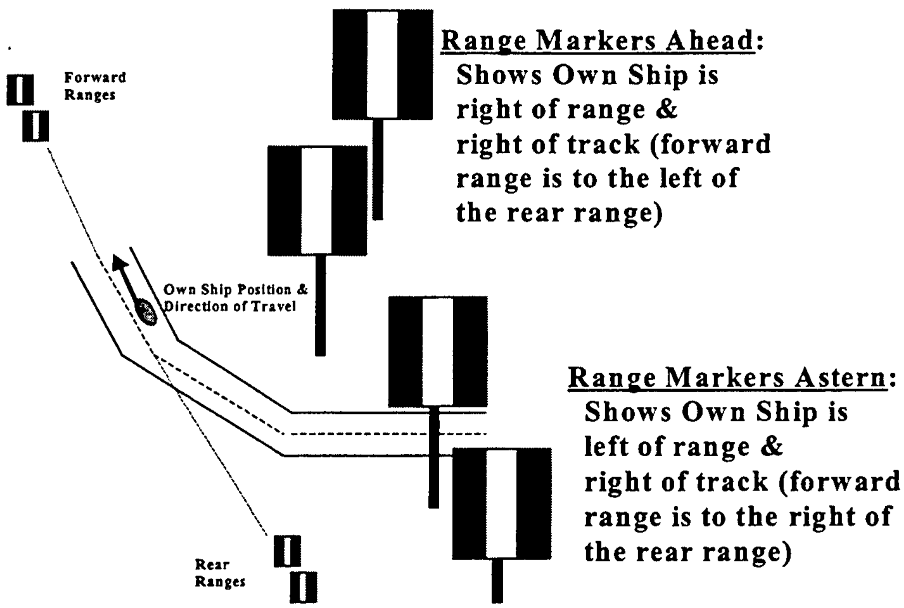

Figure 20:
Use of Range Markers to Determine Own Ship's Position Across Track

1C (Understanding the Relationship of Visual Cues to their Representation on Charts). By consulting the scale on the chart, the trainee can determine the width of the channel and by locating specific navigation aids (e.g., finding the numbers on a day marker), he can fine tune his judgment of location across the channel. Less critical than the other components, but still relevant to the task is component 2C (Understanding Relative Size and Height/Range Relationships). This cognitive component helps the OOD determine own ship's distance from navigation aids based on his perception of their size in the visual scene and his ability to relate these cues to distance estimation.

Significant learning was demonstrated on this variable for subjects at all experience levels. This indicates that VE technologies can be effectively used for both introductory and refresher training for this aspect of position determination. Trainees were able to improve their location and use of navigation aids and other cues to determine their location relative to the center of the channel. This skill is especially important in harbors like Kings Bay, because it is very narrow with shallow water on either side of the channel. The submarine OOD does not have much room for error when own ship is moving rapidly through such an unforgiving channel, making the timely and correct use of navigation aids even more essential for the safe handling of the ship.

Position of Own Ship Along Track. In addition to determining whether the ship is left or right of track, the OOD must also locate the ship's position along the track. This variable was a rating of the accuracy of the trainee's judgment of this position. A satisfactory rating was given if the trainee's reported position was within 200 yards (the approximate length of a Trident submarine) of the actual location of the ship. Otherwise, the trainee received an unsatisfactory rating.

When determining the location of own ship, utilizing all available sources of information can not be overemphasized. Various combinations of geographic features and navigation aids can be used in this task, including: relative bearings from own ship to objects and geographic features; proximity to navigational aids and buoys; own ship's size; channel width; distance to land; and chart scale. For example, if own ship was abeam (next to) a particular navigation aid, its number could be observed and found on the chart. Next, the relative bearing to a second navigation aid or geographic feature could be used to more accurately define the ship's specific location. Adding another buoy in the vicinity would further improve the accuracy.

Judging distance is another significant factor in determining the position of own ship. The size of own ship (i.e., a Trident is 564 feet long) can be used as a visual cue to help judge distances to objects. For example, some trainees used the Trident that was located in the magnetic silencing facility (MSF) to help estimate how far their own ship was from the MSF. Familiarization with harbors can also aid in determining one's position by making it easier to find various navigation aids and relate them to each other and to own ship's location.

The same perceptual and cognitive components used to judge position across track are also used to judge the position of own ship along the track. More emphasis is placed on the cognitive component 1C (Understanding the Relationship of Visual Cues to their Representations on Charts), because the OOD must use the chart more extensively to locate specific navigation aids and determine own ship's distance from them.

No significant improvement in performance was found on this variable. This is probably because the measure (satisfactory if within 200 yards of actual position) was not sensitive enough to detect small improvements in this skill area. Most of the trainees were able to use enough cues from the virtual scene to obtain a satisfactory rating during both the training and testing scenarios. Nevertheless, the VESUB system did demonstrate that the critical visual cues can be presented with enough fidelity to support this task. More sensitive performance measurement criteria for this variable should be used in the future. For example, the trainee could be required to identify own ship's position by reference to a specific location on the chart. That location could then be compared to own ship's actual position to obtain a precise numeric distance between actual and reported positions.

Contact Management

Contact management includes the ability to identify, prioritize, and avoid contacts. It is a critical skill area that the OOD must master to safely bring the ship into and out of port. The OOD must develop and maintain a mental model of the dynamic relationship of all contacts to own ship. More complex tasks, such as determining a contact's closest point of approach (CPA) and its relative motion, all depend on the accuracy and detail of the OOD's mental model. Two variables were used to measure performance in this skill area: contacts found and contacts "of concern."

Contacts Found. This variable was the ratio of the total number of contacts the trainee was able to find in the visual scene to the number of contacts that could possibly be found. Contacts were placed at various ranges and locations throughout the full 360 degree visual scene. This forced the trainee to visually search for the contacts and use binoculars as he would in the real world.

Perceptual component 4P (Locating, Identifying, and Avoiding Obstacles) is most relevant in finding contacts. Another perceptual component (2P: Judging Distance) and one cognitive component (2C: Understanding Relative Size and Height/Range Relationships, and Angle on the Bow) are relevant to a lesser degree.

No main effect for scenario session or experience level was found on this variable. However, there was a significant interaction between scenario session and experience level. Inexperienced trainees (less than one year) showed the most improvement in performance. Trainees with moderate experience (1 to 3 years) showed approximately the same performance in both the training and testing scenarios. The most experienced trainees (over 3 years) actually showed a decline in performance. This may be because the most experienced trainees did not take the simulated activities as seriously as the inexperienced trainees. They may not have taken the time to fully explore the virtual world to locate contacts as they would have in the real world. Experienced instructors often observe "traineritus" in some trainees. This is the bias that some individuals bring to training sessions. They know it's not the real world, so they may not try as hard and take the scenarios as seriously as they should. Some even try to role play or talk their way through the scenario event rather than taking the correct actions. A number of experienced persons, after making errors and receiving instruction, commented, "I knew that, but didn't think it was important in the simulation."

The research team observed increased errors in the size and distance estimations for contacts at larger distances. The expectations of experienced trainees on contact appearance might have biased them in locating distant contacts. Several contacts were purposely placed at large distances or behind partial obstructions. The most experienced trainees may have had the expectation that the simulated contacts would be easier to see and, therefore, overlooked some that were found by the inexperienced trainees, who did not have these expectations and searched more diligently. This may also be an indication that the fidelity of the contacts needs to be improved to make them as easy to find as in the real world.

Contacts "Of Concern". In addition to locating contacts, the OOD must make a determination if a contact is "of concern" in relation to own ship's intended track. A contact can be "of concern" because of its location (e.g., in the channel in front of own ship), its direction of movement (e.g., moving toward own ship), its ship type (e.g., sail boats can't maneuver quickly so they must be closely monitored), or a variety of other reasons. This variable was the ratio of the total number of contacts the trainee identified as "of concern" to the number of contacts the research team identified as "of concern."

Determining if a contact is "of concern" involves several perceptual and cognitive components of "Seaman's Eye." The most relevant components are 4P (Locating, Identifying, and Avoiding Obstacles) and 7C (Understanding Methods to Differentiate and Prioritize Traffic Contacts). Less relevant components are 2P (Judging Distance), 2C (Understanding Relative

Size/Height Relationships and Angle on the Bow), 5C (Understanding Rules of the Road), and 6C (Understanding Relative Motion).

Significant learning was demonstrated on this variable for all experience levels. This would be expected with inexperienced trainees, but is somewhat surprising for the more experienced participants. A crucial constituent of this improvement for all trainees was the recognition that even an "assist tug," working closely with own ship, should be considered "of concern." Many of the trainees, at all experience levels, overlooked this with comments like "he's working with me" or "he knows what I'll be doing." During the instructional intervention, it was explained to the trainees that the tug is still "of concern" because its position in close proximity to own ship places limits on own ship maneuverability and the OOD's reaction time in emergency situations. The key lesson is that the OOD should never become complacent when dealing with any contact.

Another area of improvement was the recognition that small pleasure boats are almost always "of concern." During the training scenario, comments like "he'll get out of the way" or "I'm the deep draft vessel with the right of way" were given as explanations for lack "of concern" about these craft. As part of the instructional intervention, it was pointed out that one can never make assumptions about what the other craft will do or whether the persons on that craft understand right of way. In contact interaction, all vessels are responsible to take early and substantial actions to avoid collisions. Understanding this information contributed to improvements during the testing scenario, probably due to the trainees' more comprehensive understanding of the concept "of concern."

General Ship Handling

A variety of general ship handling skills are required to maneuver the ship through the harbor channel. Three variables were used to measure performance in this skill area: turning commands, visually checking the rudder, and visually checking ranges.

Turning Commands. The OOD must give the command to turn at the correct time, in the correct direction, and with the correct amount of rudder. These are all determined by prevailing conditions, such as: ship's speed, ship's maneuvering characteristics (advance and transfer), set and drift, tides and currents, position left or right of track, other traffic, etc. The navigator will normally prompt this turn command with a report, "Mark the turn," based on the navigation team's assessment of these conditions. The OOD must determine if this "mark" is correct and quickly take action. This variable was the ratio of the total number of correct commands given by the trainee on all turns throughout the scenario to the number of possible correct commands.

This variable involves a large number of perceptual and cognitive components since so many elements interact in the decision process used by the OOD in making a turn. The most relevant perceptual components are 3P (Identifying the Start and Completion of Turns) and 5P (Sense of Ship's Responsiveness). The most relevant cognitive components are 3C (Understanding Advance and Transfer) and 12C (Understanding Effective Communication Procedures). Two additional perceptual and three cognitive components are also relevant to this variable: 1P (Locating and Identifying Navigation Aids), 2P (Judging Distance), 1C (Understanding the Relationship of Visual Cues to their Representations on Charts), 4C (Understanding the Effects of Tides, Currents, Wind, and Seas), and 10C (Understanding Correct Operation of Ship's Systems).

Significant improvement in the use of turning commands was demonstrated for all experience levels. All trainees executed more correct commands for turns during the testing scenario than during the training scenario. One reason for this improvement is that the feedback after the training scenario stressed that the OOD should plan ahead and be ready for the turn. Even if the OOD has forgotten the next course, when the Navigator says, "Mark the turn," the OOD should immediately give the rudder order (e.g., "Right 15 degrees rudder."), then consult his chart or course card and give the course command (e.g., "Steady course 268."). If the OOD waits to give the rudder command, precious time has been wasted and the ship could be placed in grave danger before the OOD realizes it. During the feedback session, each trainee was reminded of the "Three Minute Rule." This rule of thumb is used to help the OOD understand how far he is moving at different speeds. It states:

The distance a ship travels in three minutes (in yards) is its speed (in knots) multiplied by 100.

For example, if own ship is traveling at 12 knots, it travels 1200 yards in three minutes, 400 yards in one minute, or 100 yards every 15 seconds. Thus, if the trainee delays issuing a turning command for 15 seconds and the ship is traveling at 12 knots, the ship will be 100 yards beyond the point where the turn should have begun. In a narrow channel, such as Kings Bay, this delay could place the ship in extremis. This type of instructional feedback, combined with the experiences gained during the training scenario, prepared the trainees for better performance during the testing scenario.

Visually Checking the Rudder. Correct protocol requires the OOD to visually check the rudder each time a rudder command is issued. This is to ensure that the rudder is moving in the commanded direction so corrections may be made before the ship moves into danger. This variable was the ratio of the total number of times the trainee visually checked the rudder to the total number of rudder commands given. The cognitive component most relevant to this variable is 10C (Understanding Correct Operation of Ship's Systems).

Improvement on this variable was demonstrated for all experience levels. This indicates that even experienced individuals can forget this important task, yet their skills can be quickly refreshed. Initially, many trainees, experienced and inexperienced, attempted to solely use the rudder indicator on the simulated bridge suitcase rather than turn around and visually find the rudder. They were reminded that this indicator can malfunction and that, as the OOD, they should rely on their own eyes for this and many other tasks. The VESUB system allowed the trainee to turn to the stern, move around visual obstacles, and find the rudder. It is likely that this "full-body" experience reinforced the verbal instruction to help "automate" this critical activity.

Visually Checking Ranges. After completing a turn and coming to a new course, the OOD must visually check the ship's position right or left of the center of the channel by using the range markers found either forward or astern on each leg of the harbor channel. This variable was the ratio of the total number of times the ranges were visually checked to the total number of times they should have been checked. Perceptual component 1P (Locating and Identifying

Navigation Aids) is the most relevant to this variable, with cognitive component 10C (Understanding Correct Operation of Ship's Systems) contributing to a lesser degree.

The significant main effect of training session demonstrated that learning occurred on this variable for all trainees. There was also a significant interaction between scenario session and experience level. Even though all trainees improved between the training and testing scenarios, the degree of improvement was least for the most experienced persons and moderate for the persons with 1-3 years of experience. The least experienced persons improved the most, exceeding the performance of both the other groups during the testing scenario. In one sense, this is not surprising because the skill of using range markers to determine own ship's position across the track is a skill that is very specific to harbor ship handling, especially shallow, narrow channels like Kings Bay. The inexperienced trainees had heard lectures on the use of range markers. Some had even been through range marker exercises in small boats. However, these experiences pale before the experience of commanding a virtual ship through a realistic harbor in real time. The experienced trainees, although showing improvement, already knew how to use range markers and did not demonstrate as much improvement on this skill as did the inexperienced trainees. Some of the experienced trainees might also have been trained in northern harbors (e.g., New London), which do not demand the use of ranges. These individuals may have relied on the appearance of their position between buoys to judge their location across the track rather than using the ranges.

Another explanation for the lesser improvement among the experienced trainees is that it may be a result of the more experienced people not giving as much effort as the least experienced. It is also an indication that there were some fidelity problems with the visual representation of the ranges. Several of the experienced trainees pointed out that the representation of the range markers was not realistic enough and commented that the ranges should have been easier to find with the naked eye. Several also complained that it was difficult to differentiate between the range markers and the background textures because of insufficient contrast. Their experiences in the real world (knowing how objects actually appear) may have worked against their performance in the virtual world, leading them to give up on ranges that were too difficult to find.

Adjustments in the size of the range markers, when viewed without the binoculars, may be required and care must be taken to ensure that the range markers stand out from the background as they do in the real world. The trainee should not have to put in more effort to find range markers than he would in the real world. In this case, the more experienced trainees may not have put in this extra effort. Nevertheless, VESUB has demonstrated that it does provide effective training on the use of range markers.

Emergency Procedures

During a harbor transit, a variety of emergencies can occur. The OOD must be able to quickly and effectively deal with these emergencies to avoid loss of expensive equipment and possibly loss of life. Training on emergency tasks may be the most important contribution that VE and other simulation technologies can provide. VE allows trainees to experience emergencies in real time and requires them to exercise the skills necessary to deal with these emergencies without putting themselves, their crew, or their ship in danger.

Two emergency events occurred during the scenarios: a man overboard and a yellow sounding (a report of only 5 feet of water beneath the keel). Two variables were used to measure performance on the man overboard event (man overboard reaction time and man overboard commands) and one variable (yellow sounding commands) was used to measure performance on the yellow sounding event.

Man Overboard Reaction Time. The most important action that the OOD may take on the surface is saving the life of a man who has fallen overboard. The ship's control party has several immediate actions that must be carried out in this emergency and it is the responsibility of the OOD to ensure that they have been accomplished. This is done through the issuance of orders and through verification of each step. It is critical that the OOD issue these commands promptly and correctly. If the OOD hesitates too long before issuing the commands, serious injury or death could result.

This variable measured the time between the beginning of the man overboard event (i.e., the trainees hears "man overboard") and the time the trainee issued the first command to deal with the emergency. Cognitive components 11C (Understanding When and How to Take Corrective Actions) and 12C (Understanding Effective Communication Procedures) are the most relevant to this variable. Perceptual component 8P (Detecting and Filtering Communications) and cognitive component 6C (Understanding Relative Motion) also contributed to the skill requirements measured by this variable.

All trainees showed significant improvement on their reaction time during this emergency event. Although the more experienced trainees did not show as great a degree of improvement as the inexperienced trainees, the overall mean time to react to hearing that a man had fallen overboard by issuing the first command was reduced by 44% (from 5.34 seconds to 2.99 seconds) between the training and testing scenarios. The reduction of 2.35 seconds means that the corrective actions began before the ship had traveled an additional 16 feet (at 12 knots). Although this is not a great distance, a submarine maneuvers slowly and this could be the critical factor in allowing enough time to swing the stern away from the man before he was caught in the screw.

Man Overboard Commands. If the victim has survived the fall into the channel, he faces an immediate danger from the ship's control surfaces and the screw. The OOD must first give orders to stop the shaft so that the blades of the screw will not be turning should they make contact with the man. Then, he must give orders to swing the ship away from the man. This is accomplished by putting on a full rudder in the direction of the man. That is, if the man fell off of the starboard (right) side, the OOD orders a right full rudder to swing the stern to the left (away from the man). If the man fell off of the port (left) side, the correct command would be a left full rudder. After the man is clear, the OOD must give the necessary commands to keep own ship in good water and also take steps to retrieve the man (e.g., contact the tug on bridge-to-bridge radio). These commands may be varied slightly depending on the prevailing conditions (e.g., less than a full rudder might be used if the channel is very narrow).

This variable was the number of correct commands given by the trainee during the man overboard emergency. The most relevant component is 11C (Understanding When and How to Take Corrective Actions), with lesser contributions from components 6C (Understanding Relative Motion) and 12C (Understanding Effective Communication Procedures).

A significant main effect of scenario session was found on this variable showing an improvement of 29% on the use of correct commands during the man overboard event for all trainees. There was no significant interaction with experience level, although a slightly greater degree of improvement was found with the less experienced trainees. Data on this variable demonstrate once again that the VESUB simulation provides the context to both initially train and also to refresh critical skills.

Yellow Sounding. Yellow or red soundings are established as warning signals which indicate that the depth of water beneath the keel of the ship is too shallow for safe operation and require immediate corrective actions. The yellow sounding is a caution that the ship may be moving into danger. The red sounding indicates that the ship is in imminent danger. The depth at which a yellow or red sounding occurs is set by the Navigator and approved by the Commanding Officer. In our scenarios, yellow soundings were set at five feet and red soundings at three feet. These values were communicated to the trainees during the prebriefs for each scenario.

This variable was the total number of correct actions taken by the trainee during the yellow sounding event. Some of the actions that should have been taken by the trainee included: slowing own ship's headway; fixing ship's position; confirming direction to good water; maneuvering to seek the center of the channel or best water; sighting navigation aids; and reporting to the CO.

Perceptual component 1P (Locating and Identifying Navigation Aids) and cognitive component 11C (Understanding When and How to Take Corrective Actions) are the most relevant for this variable. Perceptual components 2P (Judging Distance) and 8P (Detecting and Filtering Communications) and cognitive components 4C (Understanding the Effects of Tides, Currents, Wind, and Seas), 10C (Understanding Correct Operation of Ship's Systems), and 12C (Understanding Effective Communication Procedures) are also associated with this variable.

Between the training and testing scenarios, a 40% improvement was demonstrated by all trainees in the actions taken during the yellow sounding event. Although the most experienced trainees started with a higher skill level than the least experienced trainees, they also demonstrated a higher skill level during the testing scenario. This indicates that VESUB provides effective refresher training for the experienced person on this task. It also indicates that the skill levels of the inexperienced trainees could probably be increased even more with additional time in VESUB.

Incorrect Report Recognition

Although the OOD is in charge, he constantly receives information from other members of the navigation team to help make decisions. It is very important that the OOD always verify the accuracy of this information rather than blindly following the reports. During the scenarios, an incorrect position report (left of track when actually right or vice versa) was given by the navigator to emphasize the importance of report verification. Only one variable (Incorrect Position) was used to assess improvements in performance in this skill area. It measured the number of correct actions taken by the trainee after receiving the incorrect position report from the Navigator.

Perceptual components 1P (Locating and Identifying Navigation Aids) and 8P (Understanding Ship's Operation Under Harbor Directives) and cognitive component 11C (Understanding When and How to Take Corrective Actions) are the most relevant to this variable. Other components that also contribute to the skills measured with this variable are: 2P (Judging Distance) and 12C (Understanding Effective Communication Procedures).

The significant main effect for scenario session showed that all trainees improved on their ability to recognize the incorrect position report. This is an indication of an improvement in the trainees' situation awareness. The trainees have become more aware of the possibility of mistakes during interactions with the Navigation Team and the possible consequences of these mistakes.

Although differential degrees of improvement were shown by persons with different experience levels, there was not enough difference to achieve a significant interaction with experience. Once again, VESUB has been shown to provide both initial and refresher training.

Communications

The OOD does not physically control the ship. He must issue commands to the navigation team in a timely and accurate manner and also verify that these commands have been correctly heard and that the correct actions are being taken. Communications with the navigation team is, therefore, one of the most critical skill areas for OOD ship handling. Three variables were used to assess the trainees' improvements in communications skills: commands to get own ship underway, use of station identifiers, and acknowledging reports.

Commands to Get Own Ship Underway. This variable was the ratio of the total number of correct commands the trainee gave when getting the ship underway to the total number of possible correct commands.

Cognitive components 10C (Understanding Correct Operation of Ship's Systems) and 12C (Understanding Effective Communication Procedures) are the most relevant to this variable. Perceptual component 5P (Sense of Ship's Responsiveness) and cognitive component 4C (Understanding the Effects of Tides, Currents, Wind, and Seas) also contribute to the skills measured by this variable.

There was no significant main effect of scenario. Although a probability of .04 was achieved, the use of a .01 significance level was the established criterion for this experiment. Nevertheless, trainees did show some improvement on this skill between the training and the testing scenarios. The lack of an interaction with experience level showed that some learning occurred for all trainees. However, there was a main effect for experience level. The most experienced trainees (over three years) started with lower levels of performance in the training scenario and demonstrated very little improvement on these skills. This may be another instance of the experienced persons not taking the scenarios as seriously as they could have.

Acknowledging Reports. The OOD must acknowledge each report received from another member of the navigation team to let them know he has heard the report. This variable was the ratio of the total number of reports that were acknowledged by the subject to the total number of reports given.

The most relevant perceptual and cognitive components to this variable are 8P (Detecting and Filtering Communications) and 12C (Understanding Effective Communication Procedures). Cognitive component 10C (Understanding Correct Operations of Ship's Systems) is also involved in these skills.

No significant main effects or interactions were found for this variable. This may show that the measure lacked sensitivity or it was not a good indicator of communications skills. It may also be the case that all trainees already fully understood the importance of acknowledging reports so that the training had no measurable effect on their performance.

Use of Station Identifiers. The Doctrine for Submarine Interior Communications (1995, p. 4-1) instruction states that each transmission consists of three parts: (a) Station called identifier (recipient); (b) Station calling identifier (originator); and (c) Text. This means that each time the OOD issues a command, he must identify to whom he is speaking and then identify himself, prior to the command. Although this "by the book" approach is not always required (e.g., when communicating to the Helm for rudder commands, p. 4-12), it was determined that for the purposes of the VESUB TEE station identifiers would always be required. The voice recognition system was programmed to give a "Say again, Sir" each time the trainee forgot to use station identifiers.

This variable measured the number of times the trainee did not use station identifiers. A significant main effect of scenario session demonstrated improvement on this skill for all trainees. Although there was no interaction with experience level, the more experienced trainees started with better scores (e.g., fewer mistakes) and also finished with better scores than the least experienced trainees. This indicates that refresher training was successful for the experienced trainees and also that additional improvements should be expected for the inexperienced trainees.

Rules of the Road

While operating in a harbor, the OOD will often have to interact with other vessels. To ensure safety during these interactions, the U.S. Coast Guard has established navigation rules of the road to which all vessels must abide (U.S. Department of Transportation, 1990) . The OOD must understand and follow these rules of the road each time he encounters another vessel. In our scenarios, a crossing situation (Rule 15, p. 31) with a ferry boat was programmed to force the trainee to follow the correct rules of the road. In this case, the ferry boat was crossing from the right (starboard) to the left (port) of own ship. This meant that the ferry was the "stand-on vessel" which allowed it to "keep her course and speed" (Rule 17, p. 33) and the own ship was the "give-way vessel" which meant it had to "take early and substantial action to keep well clear" of the other vessel (Rule 19, p. 33). The trainee had to contact the ferry to determine its intentions and take all other actions necessary to avoid a collision. As the event progressed, an agreement was reached to conduct a port-to-port passage. The trainee was required to maneuver own ship to the right side of the channel and slow enough to minimize wake damage to the small craft. One variable was used to assess performance improvements in rules of the road skills.

Ferry Passage. This variable was the total number of correct commands given during the crossing and port-to-port passage event. A large number of perceptual and cognitive components of "Seaman's Eye" are necessary to support the decision making requirements of this complex task. The most relevant perceptual component for this variable is 4P (Locating, Identifying, and Avoiding Obstacles). Three cognitive components are most closely associated with this variable: 5C (Understanding Rules of the Road); 8C (Understanding Ship's Operation Under Harbor Directives); and 12C (Understanding Effective Communication Procedures). Three additional perceptual and five cognitive variables support this task to a lesser degree: 2P (Judging Distance); 5P (Sense of Ship's Responsiveness); 8P (Detecting and Filtering Communications); 2C (Understanding Relative Size and Height/Range Relationships, and Angle on the Bow); 6C (Understanding Relative Motion); 7C (Understanding Methods to Differentiate and Prioritize Traffic Contacts); 10C (Understanding Correct Operation of Ship's Systems); and 11C (Understanding When and How to Take Corrective Actions).

Between the training and testing scenarios, significant improvement on this variable was demonstrated by trainees at all levels of experience. Trainees improved on the number of correct commands issued while dealing with the crossing situation and port-to-port passage of the ferry boat. These are especially important skills because accidents between two vessels can cause extensive damage and possible loss of life. The ability to practice these types of events in a safe simulated environment is one of the most important benefits available with VESUB.

EXPERT OPINIONS

In addition to collecting data to demonstrate the training effectiveness of the VESUB system, one of the major goals of the TEE was to collect expert opinions on the design and use of VESUB and VE technologies. Future applications of VE training systems depend on the level of support obtained from users of VESUB and other demonstration systems. Furthermore, since operational VESUB systems will be used in Navy training facilities, the opinions of instructors, trainees, and fleet experts can help determine how VE training technologies should be inserted into Navy curriculums. Opinions were collected from trainees after the testing scenario and also from observers who did not participate in the full TEE.

Trainees' Opinions

After completion of the final "Comfort" questionnaire, each trainee filled out an opinion questionnaire (Appendix G). The questionnaire included eight forced-choice questions and one open-ended question. The forced-choice questions used a five level Likert Scale with the choices "strongly agree," "agree," "neutral," "disagree," and "strongly disagree."

Learning Experience in VESUB. Questions One and Two asked about the trainee's learning experience in VESUB. Question One asked if the trainee agreed that his time in VESUB was a positive learning experience. Almost all trainees (97.7%) either "strongly agreed" or "agreed" that they learned in VESUB. No one disagreed. This is a strong indication of the positive training potential of VESUB. Even though this was a demonstration system, with only a minimal curriculum, the trainees felt they had learned meaningful skills.

Question Two asked if VESUB increased the trainee's confidence in his ship handling skills. Almost 93% of the trainees were more confident in their ship handling skills after their experience in VESUB. This increased sense of confidence will carry over to their live bridge experiences, helping them obtain more benefit from the on-the-job training.

Head-Mounted Display. The next two questions concerned the fit and adjustment of the HMD. Question Three asked if the trainee could fully adjust the HMD to his specific visual needs. Over 73% of the trainees could adjust the HMD to fit their head, but 12% could not. Making the focus adjustments easier to use would improve the design of the HMD.

Question Four asked about the comfort adjustment of the HMD. Although 90% had no comfort problems, almost 10% did. Most of these problems involved the adjustment range for head size and the padding on the top of the HMD. Additional work needs to be done to improve the design of HMDs. Reductions in weight and improvements in size range would help.

Types of Training with VESUB. Questions Five and Six concerned the type of training that was most suitable for VESUB. The fifth question asked the trainee if he agreed that VESUB should be used for introductory training. Almost all trainees responded positively to the idea of using VESUB for introductory training. In many cases, VESUB could be the first time a trainee is on the bridge. It can provide a realistic exposure to the cues that the OOD must recognize so that he is better able to adjust to his presence on the real bridge during later training. Beyond that, VESUB provides the opportunity to practice emergency tasks that would never be possible in the real world.

The sixth question asked if VESUB should be used for refresher training. Over 92% of the trainees believe that VESUB can provide effective refresher training. This is a particularly strong recommendation, given that so many of the trainees were highly experienced ship handlers.

Location of Training. The seventh forced-choice question dealt with where training should be delivered. It asked if the trainee agreed that VESUB should only be used in the classroom for shore-based training. Although 50% of the trainees disagreed that VESUB should only be used ashore in the classroom, there may have been some confusion about this question. It is the only question that was worded so that a positive response was "disagree." A few trainees may not have carefully read the question and answered "agree" because it was the pattern they had followed on the other questions. Nevertheless, these responses indicate that VESUB could be used for training in other contexts besides the classroom (e.g., aboard the ship).

Mission Rehearsal. The last forced-choice question asked the trainees' opinions on the use of VESUB for mission rehearsal aboard the submarine. This question might also have confused some trainees. They may not have understood what was meant by mission rehearsal. Even so, over 50% of the trainees felt that the system could be used to practice missions.

Open-ended Comments. The open-ended question provided an opportunity for the trainees to state any suggestions for improving VESUB or opinions about the VESUB system. Their comments were grouped into several content areas.

General Reactions to the System. Trainees were very positive about their experiences in VESUB. Adjectives such as great, outstanding, and excellent were used throughout their comments. Almost all the trainees thought the learning potential of VESUB was very high. Only one negative comment was received from a trainee who had to be removed from the system due to simulator after effects.

Instructional Tools or Approaches. Trainees appreciated the opportunity to practice in situations where no one was in danger. They also liked the opportunity to obtain incorrect information (e.g., the incorrect navigator report) and be able to take corrective actions in a safe environment.

Voice and Sounds. The voice recognition system was recognized as an integral component of the system. It was also an area that received a large number of suggestions for improvement. The largest number of suggestions concerned the ability of the OOD to override the speech generation system. In the demonstration, the system could not hear the trainee when it was speaking to him. This became quite cumbersome, especially in emergency events. The OOD's microphone should turn off the speech synthesis system any time it is activated. The requirement to use station identifiers (e.g., "Helm, Bridge...) was not appreciated by some trainees, although others saw value in requiring them. The best approach would be to have the system recognize the command without the station identifiers, but record that the trainee did not use them. Later, the instructor could provide feedback to improve performance in this area. Other comments concerned fine tuning the speed of both the voice recognition and synthesis systems.

Environmental sounds were highly regarded and several suggestions to improve their realism were made by the trainees. The sounds of wind and waves can provide speed cues and directional sounds can help the trainee locate contacts and nearby navigation aids.

Visual Scene and Visual System. The most important suggestion in this area is to replace the voice-activated binocular function with a physical switch on the HMD. The voice command for binoculars was included in the original feasibility demonstration system and carried over to VESUB. It seemed a good idea until the ship handling vocabulary was fully implemented. The voice activation for binoculars became too cumbersome when trying to issue other commands. The operational VESUB system should include a switch on the HMD that will activate the binoculars only when held down and revert to naked eye view when released.

Several suggestions were made to improve the appearance of the visual scene. The contrast between navigation aids and background textures was seen as an area where improvement was needed, as was the appearance of contacts. Several observers mentioned that the distance to contacts could be more accurately estimated if the database provided curvature of the earth. In the real world, contacts at large distances fall below the horizon and become "hull down," where only their masts and upper decks are visible. In our databases, the earth is flat and the contacts display their entire structure at all ranges providing inaccurate distance cues.

Improvements were also suggested to make the bow wave and stern wake more realistic to provide more accurate speed cues. As the ship increases speed, the bow wave should move toward the sail and become more pronounced and blend with the stern wake. The stern wake should extend much farther (up to several miles) than in the current display.

Submarine Model. One trainee thought the submarine responded too quickly to speed (bell) orders. Most, however, thought the models were accurate enough for training purposes with the exception of the way own ship bounced over the waves rather than pushing under them. Several suggested that collision detection should also be included in the model. This would provide an indication when the submarine touched a contact, the bottom, navigation aids, or piers.

Use of the System. Almost all trainees agreed that the system was useful for introductory and refresher training. A couple of suggestions were made to allow all members of the Navigation Team to train in VESUB. This would give each team member a better understanding of the requirements and information needs of the OOD.

Head-Mounted Display. The TEE was an opportunity to allow trainees to wear the HMD for an extended period of time (almost 3 hours). Some trainees suggested additional padding to make the HMD more comfortable. Others suggested better fit and focus adjustment capabilities. A wider field of view was desired by almost all trainees.

Haptic Capabilities. One trainee suggested the inclusion of a virtual hand in the visual scene to assist the OOD in taking bearings or enabling him to touch virtual bridge equipment. Several other trainees provided similar verbal comments. This would require a separate hand tracker, but should not be too difficult and would improve the realism of the system.

Observers' Opinions

Observers of the TEE filled out an opinion questionnaire (Appendix H). It consisted of six forced-choice and one open-ended question.

Training Potential of VESUB. The first two questions asked the observers' opinions about the training potential of VESUB. Question One asked if the observers agreed that VESUB provided a positive learning experience. All of the observers answered positively on this question, demonstrating that even without extensive experience in VESUB, they recognized its capabilities to provide effective instruction. On Question Two, over 90% of the observers believed that experience with VESUB would improve a trainee's confidence in his ship handling skills.

Types of Training. Whether VESUB should be used for introductory training, refresher training, or both were addressed in Questions Three and Four. Almost all (98%) of the observers agreed that it should be used for introductory training and 91% thought it could also be used for refresher training. Data, discussed earlier, showing that learning occurred with trainees at all experience levels, support the opinions of the observers that VESUB should be used for both introductory and refresher training of ship handling skills.

Where to Train. Questions Five and Six concerned whether VESUB should be used only in the classroom or deployed aboard ships. Reactions were mixed on whether it should only be used in the classroom (54% disagreed). However, the wording of this question called for a reversal in the pattern of responses, possibly confusing some respondents.

Although their responses were mixed, over half of the observers agreed that VESUB could be deployed and used for mission rehearsal. Many additional issues must be resolved before VESUB can be used in this manner. For example, the size of the computer hardware must be reduced and some method to download databases or to maintain a database library would be required. Additional research will eventually provide this capability.

Open-ended Suggestions. The observers provided numerous comments in the open-ended section of the questionnaire. Their suggestions were grouped into several content areas.

General Reactions to the System. The observers' general reactions to the system were very positive. The current configuration was viewed as an excellent first step with great potential.

System Expansions. Even though they recognized the potential of VESUB, the observers suggested ways to expand the capabilities of the system. An open ocean database would allow training of tasks such as underway replenishment and personnel transfers. Observers also mentioned the need for training in mooring and docking procedures. These tasks are difficult and have the potential for damage to own ship and assist tugs. A mooring and docking capability was minimally available in the configuration of the demonstration system, but needs considerable improvement in the operational systems.

Interfacing VESUB with the existing Submarine Piloting and Navigation (SPAN) trainer was an original goal of the research effort. Unfortunately, budget and schedule constraints did not allow this. Observers suggested that integration of OOD training with other team members (maneuvering watch and piloting teams) would be highly beneficial. The operational VESUB systems will need to be developed to include the capabilities to interface with other team members. It was also suggested that VE technologies could be used for other tasks, such as maintenance training.

Instructional Tools. Highlighting of channel boundaries and centerline was available in the demonstration system. Most people thought this was a great idea. However, both sides of the channel were represented with green lines. A logical suggestion was to make the red buoy side red and the green buoy side green.

Voice and Sounds. The voice and sound system was seen as very important for successful training. Several suggestions were made to improve these capabilities. The most useful suggestion was to implement the voice recognition so it understands the trainee, even when the voice synthesis system is speaking. This is critical in fast-paced, emergency situations when every second counts. The system was implemented to require station identifiers (e.g., "Helm, Bridge") before each command. Although this is "by the book," the system needs to be able to understand, even without the station identifiers. In emergency situations, it is not realistic to have the system say "Say Again, Sir" when station identifiers are forgotten. It needs to record this mistake, but still follow the command. The binocular command was also seen as cumbersome in emergency situations. Use of a mechanical switch to turn binoculars on and off will alleviate this problem.

Visual Scene and Visual System. Several suggestions were provided to make the visual scene more realistic. Adding additional bridge equipment (Radar, GPS, a means to display contact positions) are all features that should be considered in the operational system, depending on their availability on the bridge of the selected ship class. Technological innovations will allow the visual fidelity of the environment, the visual refresh rate, and field of view to be improved.

Virtual Crew. The addition of the Contact Coordination was seen as essential both from the perspective of the trainee and the instructor. Playing the role of the Contact Coordinator requires far too many instructor resources that could be better used observing and coaching the trainee. The Contact Coordinator is the most complex virtual crewman since the system must deal with a higher level of free speech than with other stations. Development of this capability will require innovative modeling of the Contact Coordinator's job and improved logic in the voice recognition system.

Addition of Haptic Capabilities. The addition of haptic (touch and feel) capabilities was suggested by several observers. This will allow the trainee to interact more realistically with bridge equipment, such as the compass alidade and the microphone. Even the minimal addition of a virtual body in the trainee's visual scene could improve his spacial orientation and probably enhance training. Additional research is needed to determine how existing and emerging haptic capabilities can be incorporated in future VR systems.

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CONCLUSIONS AND RECOMMENDATIONS

The VESUB R&D technology demonstration system is one of the first VE training systems to be developed at a comprehensive enough level to be evaluated at training facilities. Even so, it is not a complete training system. Although learning was demonstrated on quite a few critical variables in important skill areas, many ship handling skills were not evaluated in the VESUB demonstration system. In some cases this is because the capability to train these skills was not available in the VESUB demonstration system. In other cases, time and budget constraints did not allow the evaluation of these skills areas in the TEE. Nevertheless, the results of the TEE do point to several important conclusions and recommendations:

- VESUB provides effective ship handling training
- All experience levels can benefit from VESUB training
- Event-based curriculum development is recommended
- Instructor training is essential
- VESUB is the first step toward SPAN 2000
- Improvement and expansion of the virtual crew is required
- Team training can be improved with the use of simulated team members

VESUB PROVIDES EFFECTIVE SHIP HANDLING TRAINING

Data from the TEE on eleven of fifteen variables showed significant learning in a variety of ship handling skill areas. It can be said with confidence that VESUB technologies can provide effective training. However, a training system is far more than just technologies. It can not be stated too strongly that a training system will only be effective if it is used correctly. Care must be taken to implement the technologies in VESUB in a manner that is consistent with known learning principles.

ALL EXPERIENCE LEVELS CAN BENEFIT FROM VESUB TRAINING

Data on almost every variable showed that trainees with every level of experience can benefit from training in VESUB. Very inexperienced trainees, those that have never been on the bridge of a submarine, can experience the feelings and events of a real-time, high fidelity simulation that provides most of the cues that must be dealt with in the real world. Simulations will not replace on-the-job training on the submarine bridge, but the inexperienced JO can bring what he has learned in the VE to the bridge and, therefore, obtain more benefits from the on-the-job training than otherwise. Furthermore, he can obtain training on tasks that are not always available or possible on the submarine due to time and safety constraints.

The experienced trainee, perhaps because he has been on a shore assignment, can forget critical elements of ship handling tasks. The TEE demonstrated that even persons with over 10 years experience can improve their ship handling skills. Prospective COs and XOs can be more confident in their ability to train and evaluate their JOs if their own skills are fresh in their minds. VE training systems, like VESUB, will eventually be less costly so they can be made available to persons at all levels of experience.

EVENT-BASED CURRICULUM DEVELOPMENT IS RECOMMENDED

Any training system will only be effective if it is used in a well designed instructional curriculum. For the purposes of the TEE, an abbreviated curriculum was developed to target several important skill areas. An event-based approach was used to design scenarios that allowed the trainees to experience the critical cues required for ship handling tasks and to practice the skills required to successfully accomplish them. The operational VESUB systems will provide effective training if a similar approach is followed. Curriculum developers (or instructors) must target the critical skills required to support all elements of ship handling (e.g., the perceptual and cognitive components of "Seaman's Eye"). Then, they must provide the scenario events and the instructional interventions which will allow trainees to improve these skills.

INSTRUCTOR TRAINING IS ESSENTIAL

We can not expect Navy instructors to be training experts unless they are provided with the necessary support to reach this goal. A well designed instructor/operator station can help by making the instructor's job easier (see Hays, et al., 1997). This alone is not enough. Instructors need to be trained on effective instructional techniques. With new training technologies come new responsibilities for the instructor. They need to understand the capabilities of the training system and how to use these capabilities to achieve the best results. On-line help and advice can be a part of this training as can a well designed training system instructor's manual. However, these are not sufficient. Instructors must be trained to understand that learning is a multistep process. Each trainee must receive instruction, be allowed to practice relevant skills, and be given constructive performance feedback. If instructors learn how to excel in all these areas, trainees will learn more effectively.

VESUB IS THE FIRST STEP TOWARD SPAN 2000

One of the original goals of the VESUB R&D project was to interface with the existing Submarine Piloting and Navigation (SPAN) trainer. All the other members of the Navigation Team, except the OOD, train on SPAN. Although some progress was made toward this goal, the outdated hardware and software in SPAN made it too difficult to interface with newer VESUB software with the resources available in the R&D project. Nevertheless, it is important to provide a system that will support live training for the entire Navigation Team. Plans are in place for operational VESUB systems and also for future SPAN trainers. It is strongly recommended that, rather than trying to interface the new VESUBs with existing SPANs, the image generation and geographic location software from VESUB be used to drive the periscope, radar, and other equipment in the future SPAN systems. This approach will provide improved visual capabilities in SPAN and also bring the OOD into live team training with other members of his team.

IMPROVEMENT AND EXPANSION OF THE VIRTUAL CREW

An important part of the VESUB demonstration was the development of several virtual crew members. The Helm, Navigator, and Maneuvering were simulated ("virtualized") so the OOD could realistically interact with them without the necessity for the instructor to play these roles.

This capability needs to be improved and expanded to other crew members. For example, the Contact Coordinator position is vital for providing accurate and timely information to the OOD on the status of contacts. Resources did not allow the completion of this virtual position, but it should be included in the operational VESUB systems.

Even the positions that were included in the virtual crew need to be improved. Repeat backs of commands need to be faster and recorded in a clearer voice. Recognition of commands needs to occur even without the use of station identifiers, although the system should record each time the trainee fails to use them. In emergency situations, like man overboard, the Helm would not say "Say again, Sir" when ordered "Left full rudder." He would go ahead and execute the command. The virtual helm must also perform this way.

A communications log with a time tag on each recognized phrase and synthesized command should be provided as part of the performance feedback materials collected by the system (see below). This log will provide the opportunity for the instructor to coach the trainee on the use of station identifiers and correction of other mistakes made during the training scenario.

TEAM TRAINING WITH SIMULATED TEAM MEMBERS

The experiences gained in the development and use of the virtual crew in VESUB can be of great benefit in the development and use of simulated team members for both the operational VESUB and other future training systems. As training resources are reduced, it becomes more and more important to have flexible training options. Since most military tasks are done in teams, team training is vital for successful task performance. However, team training can not always be conducted with an intact team. One or more critical team members may be ill or away because of an emergency. The rest of the team has few options. They may work around the missing team member, have someone else play that role, or wait until he or she returns. Simulated team members can allow the team to engage in meaningful training even if one or more team members are not available. Alternatively, a team member in need of remedial training could work with an entire simulated team, improving his or her skills without engaging the rest of the team. Once proficiency has been obtained, the team member could return to live training.

This can only work if each simulated team member is developed with enough realism to support the needs of the rest of the team. This means that each team position has to be modeled and this model implemented so that the live team members do not recognize when another persons is real or simulated. Tasks like submarine OOD ship handling training are the perfect context for developing these capabilities because the vocabulary is relatively fixed and no face-to-face communication is required.

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COORDINATION

The VESUB technology demonstration system evolved from a feasibility demonstration system, developed under the Virtual Environment Training Technology project at NAWCTSD. This feasibility demonstration was used during the first year of the VESUB project to solicit inputs from fleet Subject Matter Experts (SMEs) on the required functionality for the VESUB technology demonstration system. During development and formative evaluations of VESUB, numerous fleet SMEs provided guidance to ensure that the system was realistic and provided the necessary functionality to support training for the ship handling task. Additional guidance on future system functionality was provided by several instructors from SUBTRAFAC, Norfolk, VA and NAVSUBSCOL, Groton, CT, as well as personnel from several submarines during the TEE.

The development of VESUB has been immeasurably aided by the support and guidance of the VESUB Implementation Planning Group (IPG). The IPG included members from:

- CNO (N879C), Washington, DC
- CNET (T2223), Pensacola, FL
- COMSUBLANT (N742), Norfolk, VA
- COMSUBPAC, Pearl Harbor, HI
- COMSUBGRP Ten, Kings Bay, GA
- NAVSUBSCOL (N52), Groton, CT
- SUBTRAFAC (Code 10), Norfolk, VA
- TRITRAFAC, Kings Bay, GA
- TRITRAFAC, Bangor, WA
- SUBTRAFAC, San Diego, CA

VESUB has been demonstrated to hundreds of visitors to the NAWCTSD laboratories and at two major conferences (the 1997 Navy League Sea Air & Space Exposition and the 1997 Interservice/Industry Training Systems and Education Conference). The success of the integration of hardware and software in VESUB has led to the use of several components in other training systems.

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GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS

AHD	Ahead
AME	Nichols/Advanced Marine Engineering (formerly Advanced Marine Enterprises), VESUB System Developers
ANAV	Assistant Navigator
AOB	Angle on the Bow
AST	Astern
CO	Commanding Officer
COTS	Commercial Off the Shelf
CPA	Closest Point of Approach
GUI	Graphical User Interface
HCI	Human-Computer Interface
HMD	Head Mounted Display
IALA	International Association of Lighthouse Authorities
IOS	Instructor/Operator Station
JO	Junior Officer
LADBM	Large Area Database Management
NAVAID	Navigation Aid
NAVSUBSCOL	Naval Submarine School
NAWCTSD	Naval Air Warfare Center Training Systems Division
NTDS	Naval Tactical Data System
OOD	Officer of the Deck
SIMGEN	Simulation Generation Software on VESUB and Virtual Ship
SME	Subject Matter Experts
SPAN	Submarine Piloting and Navigation Training System
SS	Submarine Qualified
SUBTRAFAC	Submarine Training Facility
TEE	Training Effectiveness Evaluation
VE	Virtual Environment (synonymous with VR)
VESUB	Virtual Environment for Submarine OOD Ship Handling and Piloting Training System
VETT	Virtual Environment Training Technology (6.2 Research Program at NAWCTSD)
Virtual Ship	AME's Commercial Surface Ship Handling Training Product (baseline for VESUB)
VR	Virtual Reality (synonymous with VE)
XO	Executive Officer

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APPENDIX A

VESUB Hardware and Software

HARDWARE

Main Computer System: Silicon Graphics Onyx Deskside
- Four R10,000 CPUs
- 256 Mbytes RAM
- One Infinite Reality Graphics Pipe with Two Raster Manager Boards (16 MB Texture Memory)
- Scene Refresh Rate at up to 30 Hz
- Capable of Displaying Approximately 21,000 Polygons (fully Z-buffered and anti-aliased)

Instructor/Operator Station (IOS):
- Two Silicon Graphics INDY Desktop Computers

Head Mounted Display (HMD): n-Vision Datavisor HiRes
- Resolution: 1280 x 1024 pixels
- Field of View: 40 degrees horizontal and 30 degrees vertical (capable of stereo-optics for up to 70 degrees horizontal view)

Head Tracker: Polhemus 3 space Fastrack (Magnetic)

Printer: Epson, Stylus Color 800

Sound System:
- Two Radio Shack SSM60 Stereo Sound Mixers
- Two Rane MS1 Microphone Amplifiers
- Two Radio Shack Dynamic CB Microphones, P/N 21-1172
- Two Radio Shack Speakers, Cat. No.: 40-1324

SOFTWARE

Visual Scene:
- Models and Terrain Created Using ModelGen2 from Multigen, Inc.
- Real-time, Interactive 3-D Scene Generation Controlled by SGI's IRIS Performer
- Marine Visual Effects Created Using Vega Marine from Paradigm Simulation, Inc.

Instructor/Operator Station (IOS) Interface:
- IOS Screens Created Using Visual Applications Builder (VAPS) from Virtual Prototypes, Inc.
- Windows in SIMGEN and Start-up Screens Created with X-Designer Release 4.5 from Imperial Software Technology Limited and Data Views Corporation

Voice Recognition & Synthesis: HARK, developed by Bolt, Beranek & Neuman, Inc. Implemented by UFA, Inc.

Audio Effects:
- Audioworks from Paradigm Simulation, Inc.

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APPENDIX B

VESUB Training Objectives

PERCEPTUAL COMPONENTS	TRAINING OBJECTIVES
1P. Locating and Identifying Navigation Aids	• The trainee shall be able to locate navigation aids when referenced by the navigator. • The trainee shall be able to recognize navigation aids in the visual field and relate them to the chart.
2P. Judging Distance	• The trainee shall be able to accurately judge distances to: navigation aids, contacts, and landmarks. • The trainee shall be able to judge distances relative to track. • The trainee shall be able to verify known distances using environmental cues and chart work. • The trainee shall be able to maintain the ship within the acceptable limits of the channel.
3P. Identifying Start and Completion of Turns	• The trainee shall be able to determine relative and true directions on a compass. • The trainee shall be able to determine relative bearings to the navigational aid to be used for turn bearings. • The trainee shall check turn bearings when turning. • The trainee shall be able to recognize when the ship is clear to turn (e.g., when buoys are in line).
4P. Locating, Identifying, and Avoiding Obstacles	• The trainee shall look far enough ahead to evaluate contacts early. • The trainee shall be able to recognize new contacts prior to being informed of the contact. • The trainee shall be able to recognize relative directions and motions. • The trainee shall be able to locate, identify, classify and differentiate between various types of contacts and other obstacles (e.g., debris, aquatic animals). • The trainee shall take early and effective actions to avoid obstacles or lessen their negative outcomes.
5P. Sense of Ship's Responsiveness	• The trainee shall understand the ship's capabilities and limitations, including: advance and transfer, speed at various engine orders, loss of steerage way, distance to stop or reverse course.
6P. Recognizing Environmental Conditions	• The trainee shall be able to accurately estimate: sea state, cloud cover, direction and velocity of current, wind direction and speed, and time of day. • The trainee shall be able to accurately judge the state of visibility.
7P. Recognizing Equipment Failures	• The trainee shall stay alert for equipment failures. • The trainee shall regularly monitor rudders, indicators, and other equipment.
8P. Detecting & Filtering Communications	• The trainee shall be able to recognize communication sources and proper/improper repeat backs.

APPENDIX B: VESUB Training Objectives (Continued)

COGNITIVE COMPONENTS	TRAINING OBJECTIVES
1C. Understanding the Relationship of Visual Cues to Chart(s)	• The trainee shall be familiar with all the navigation aids to be used. • The trainee shall understand how to read ranges (fore and aft). • The trainee shall understand how to determine if the ship is left/right of track versus left/right of range. • The trainee shall understand when to attempt to drive the ship in the center of the channel. • The trainee shall understand buoyage systems (e.g., IALA "A" and "B" systems). • The trainee shall understand the inaccuracy of buoys. • The trainee shall understand the accuracy/inaccuracy of Fix information.
2C. Understanding Relative Size and Height/ Range Relationships, and Angle on the Bow	• The trainee shall understand how to determine contact mast head height. • The trainee shall know his height of eye. • The trainee shall know how to determine: size and distance relationships to navigation aids, contact length, distance to the horizon, hull down, and angle on the bow.
3C. Understanding Advance and Transfer	• The trainee shall understand the concepts of advance and transfer. • The trainee shall understand ship characteristics like tactical diameter of own ship. • The trainee shall understand the criticality of turning the vessel the wrong way. • The trainee shall understand the principles of conning the ship through turns. • The trainee shall understand when to turn the ship based on the use of a slide bar. • The trainee shall understand the principles of compensation. • The trainee shall compensate for set and drift when making turns. • The trainee shall check that the next channel is clear prior to turning. • The trainee shall not drive based solely on the Navigator's recommendations.
4C. Understanding the Effects of Tides, Currents, Wind, and Seas	• The trainee shall understand how the wind affects the height of seas. • The trainee shall understand that current and tides tend in the direction of the natural geography. • The trainee shall understand the relationship of the estimated winds associated with various sea heights. • The trainee shall understand that sea height influenced by wind speed can give false indications of the actual direction of currents.
5C. Understanding Rules of the Road	• The trainee shall comprehend the criticality of Rules of the Road. • The trainee shall correctly exercise Rules of the Road by taking appropriate actions in: overtaking, meeting, passing, and crossing situations. • The trainee shall understand the rules for sound signals and responses. • The trainee shall take appropriate action when nearing a bend in the channel. • The trainee shall take appropriate actions to avoid collisions.
6C. Understanding Relative Motion (Direction & Speed)	• The trainee shall understand true and relative bearing and their significance. • The trainee shall be able to convert relative to true and true to relative. • The trainee shall be able to determine the relative direction of contacts. • The trainee shall be able to determine own ship's motion relative to fixed objects.

APPENDIX B: VESUB Training Objectives (Continued)

COGNITIVE COMPONENTS	TRAINING OBJECTIVES
7C. Understanding Methods to Differentiate and Prioritize Traffic Contacts	• The trainee shall be able to classify, differentiate, and prioritize various types of contacts and other obstacles. • The trainee shall understand safe distances to hazards. • The trainee shall be able to effectively determine contacts of interest. • The trainee shall correctly assign master control numbers to contacts of concern. • The trainee shall maintain awareness of contacts in relation to own ship. • The trainee shall prompt personnel for supporting information. • The trainee shall drop contacts of interest when no longer of concern. • The trainee shall be able to correctly determine contact's angle on the bow.
8C. Understanding Ship's Operation Under Harbor Directives	• The trainee shall understand harbor, port limitations, restrictions, & regulations.
9C. Understanding Methods to Deal with Uncooperative Traffic	• The trainee shall take proper and effective actions to avoid encounters with uncooperative traffic.
10C. Understanding Correct Operation of Ship's Systems	• The trainee shall understand the correct operation of bridge equipment. • The trainee shall verify rudder orders by: visually checking the rudder and the bridge suitcase indicator. • The trainee shall verify engine orders by: checking the bridge suitcase indicator and observing screw wash.
11C. Understanding When and How to Take Corrective Actions	• The trainee shall understand emergency operating procedures.
12C. Understanding Effective Communication Procedures	• The trainee shall speak clearly. • The trainee shall use correct terminology. • The trainee shall effectively communicate with each station using required terminology. • The trainee shall acknowledge all reports and repeat backs. • The trainee shall inform appropriate personnel about his actions. • The trainee shall not clutter the circuits.

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APPENDIX C

Demographic Information on Trainees in the VESUB TEE

Ss #	Rank	Age	Assignment	Exp	Glas	ConLen	Astig	Vision
N-1	ETC	35	Instructor	6	Y	Y	N	Good
N-2	CIV	45	Harbor Pilot	18	N	N	N	Good
N-3	ETCS	33	ANAV	14	N	N	N	Very Good
N-4	LT	33	Navigator	9	N	N	N	Very Good
N-5	LT	26	JO	1	Y	N	N	Poor
N-6	LT	27	Instructor	4	N	N	N	Medium
N-7	LTJG	25	JO	0.5	Y	N	N	Poor
N-8	LT	27	Instructor	3	N	Y	N	Very Poor
N-9	LT	26	JO	2	Y	N	N	Medium
N-10	LT	31	Navigator	5	Y	N	Y	Very Poor
N-11	ENS	23	JO	0	Y	N	N	Good
N-12	LTJG	25	RCA	0	N	N	N	Good
N-13	LT	33	Instructor	4	Y	N	Y	Good
N-14	LTJG	27	JO	1	Y	N	N	Medium
N-15	LTJG	29	JO	1	N	N	N	Good
N-16	LCDR	36	XO	12	Y	N	N	Medium
N-17	LT	27	Asst Ops	3	Y	N	Y	Poor
N-18	LT	29	JO	3	N	Y	N	Poor
N-19	LTJG	25	JO	0.5	Y	N	N	Poor
N-20	CDR	38	SUBLANT Staff	16	N	N	N	Very Good

Notes: N = Norfolk; G = Groton
Assignment = Current Assignment; Exp = Yrs. of Ship Handling Experience;
Glas = Wear Glasses? ConLens = Wear Contact Lenses? Astig = Astigmatism?
Vision = Self Rating on Uncorrected Vision

APPENDIX C:

Demographic Information on Trainees in the VESUB TEE (Continued)

Ss #	Rank	Age	Assignment	Exp	Glas	ConLen	Astig	Vision
G-1	LT	33	Instructor	3	N	N	N	Good
G-2	LTJG	24	JO Springfield	.25	Y	N	N	Good
G-3	LTJG	24	JO Billfish	.25	Y	N	Y	Medium
G-4	LTJG	26	JO Connecticut	1	N	N	N	Good
G-5	LTJG	24	JO Philadelphia	0	N	N	Y	Good
G-6	LTJG	24	JO Connecticut	.5	N	N	N	Good
G-7	ENS	25	JO Boston	.3	Y	Y	N	Very Poor
G-8	ENS	32	JO Miami	.5	N	N	N	Good
G-9	LT	28	SSCOL Staff	3	Y	Y	N	Poor
G-10	LT	29	Instructor	3	N	Y	Y	Poor
G-11	ENS	26	SOBC	0	Y	Y	N	Medium
G-12	LT	29	Instructor	3	Y	N	N	Medium
G-13	ENS	23	SOBC	0	N	Y	Y	Very Poor
G-14	ENS	30	SOBC	0	Y	Y	Y	Good
G-15	ENS	23	SOBC	0	N	N	N	Good
G-16	LT	27	Instructor	3	N	Y	Y	Poor
G-17	ENS	25	SOBC	0	Y	Y	N	Med/Poor
G-18	LTJG	30	JO Miami	1.5	N	N	N	Very Good
G-19	LTJG	23	SOBC	0	Y	N	N	Poor
G-20	LTJG	25	JO Miami	1	Y	Y	N	Poor
G-21	LT	27	Communicator , Augusta	3	N	N	N	Medium`
G-22	LT	30	SUBSCOL Staff	4	N	N	Y	Good

Notes: N = Norfolk; G = Groton
Assignment = Current Assignment (JO = Junior Officer; SSCOL = Submarine School; SOBC = Submarine Officer Basic Course); Exp = Yrs. of Ship Handling Experience; Glas = Wear Glasses? ConLens = Wear Contact Lenses? Astig = Astigmatism? Vision = Self Rating on Uncorrected Vision

APPENDIX D

Demographic Information on Observers of the VESUB TEE

Rank	Age	Assignment	Exp	Location
Civ	55	Chief Harbor Pilot	20	Norfolk
LT	29	Instructor – SUBTRAFAC	4	Norfolk
LCDR	-	Exec. Officer – USS Hampton	-	Norfolk
CAPT	44	COMSUBRON Four	23	Groton
LT	28	SOBC Prog Mgr	3	Groton
CDR	41	Dir Officer Training NAVSUBSCOL	23	Groton
LCDR	34	NAVSUBSCOL – N26	10	Groton
LT	29	Instructor, NAVSUBSCOL	5	Groton
LT	31	SUBRON Four	6	Groton
LT	26	NAVSUBSCOL – COMS COR	1	Groton
STSCS	41	NAVSUBSCOL – Dept Master Chief	23	Groton
ENS	23	SOBC	0	Groton

Notes: Assignment = Current Assignment; Exp = Yrs. of Ship Handling Experience; COMSUBRON = Commander, Submarine Squadron; SOBC = Submarine Officer Basic Course; NAVSUBSCOL = Naval Submarine School

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APPENDIX E

VESUB TEE Trainee Demographic Data Collection Form

VESUB TRAINING EFFECTIVENESS EVALUATION

Background Information:

NAME & RANK ______________________________

AGE _________

CURRENT ASSIGNMENT ___________________________

YEARS OF SHIP HANDLING EXPERIENCE ___________

Do you wear glasses? Y / N

Do you wear contact lenses? Y / N

Do you have an astigmatism? Y / N

Please rate your uncorrected vision.
Very Good Good Medium Poor Very Poor

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APPENDIX F

VESUB TEE "COMFORT" QUESTIONNAIRE

Pre-Experience Comfort Questionnaire

Instructions: Please circle the severity of any symptoms that apply to you <u>right now</u>.

	(0)	(1)	(2)	(3)
1. General Discomfort	None	Slight	Moderate	Severe
2. Fatigue	None	Slight	Moderate	Severe
3. Headache	None	Slight	Moderate	Severe
4. Eye Strain	None	Slight	Moderate	Severe
5. Difficulty Focusing	None	Slight	Moderate	Severe
6. Increased Salivation	None	Slight	Moderate	Severe
7. Sweating	None	Slight	Moderate	Severe
8. Nausea	None	Slight	Moderate	Severe
9. Difficulty Concentrating	None	Slight	Moderate	Severe
10. Fullness of Head*	None	Slight	Moderate	Severe

*internal pressure in head, similar to sinus pressure

11. Blurred Vision	None	Slight	Moderate	Severe
12. Dizzy (Eyes Open)	None	Slight	Moderate	Severe
13. Dizzy (Eyes Closed)	None	Slight	Moderate	Severe
14. Vertigo**	None	Slight	Moderate	Severe

**Vertigo is a disordered state in which the person or his/her surroundings seem to whirl dizzily; giddiness

15. Stomach Awareness***	None	Slight	Moderate	Severe

***Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea

16. Burping	None	Slight	Moderate	Severe

Are there any other symptoms that you are experiencing <u>right now</u>? If so, please describe the symptom(s) and rate their severity on the other side.

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APPENDIX G

VESUB TEE TRAINEE OPINION DATA COLLECTION FORM

PLEASE ANSWER THE FOLLOWING QUESTIONS ABOUT THE VESUB SYSTEM

(please circle the response that <u>most closely</u> matches your assessment)

1. I had a positive learning experience in the VESUB system.
strongly agree agree neutral disagree strongly disagree

2. Training with VESUB will increase my confidence in my ship handling skills.
strongly agree agree neutral disagree strongly disagree

3. I was able to fully adjust the VESUB HMD to meet my specific visual needs.
strongly agree agree neutral disagree strongly disagree

4. I was able to fully adjust the VESUB HMD to comfortably fit my head.
strongly agree agree neutral disagree strongly disagree

5. VESUB should be used for introductory ship handling training.
strongly agree agree neutral disagree strongly disagree

6. VESUB should be used for refresher training for ship handling skills.
strongly agree agree neutral disagree strongly disagree

7. VESUB should only be used in a classroom (shore-based training).
strongly agree agree neutral disagree strongly disagree

8. VESUB should be installed on submarines for mission rehearsal and refresher training.
strongly agree agree neutral disagree strongly disagree

9. Please provide any additional suggestions that would improve the realism, performance or training effectiveness of VESUB. (Please continue on the back if necessary.)

____

____

____

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APPENDIX H

VESUB TEE Observer Questionnaire

VESUB TRAINING EFFECTIVENESS EVALUATION

Observer Questionnaire

Background Information:

NAME & RANK ______________________________

AGE __________

CURRENT ASSIGNMENT ____________________________

YEARS OF SHIP HANDLING EXPERIENCE ____________

PLEASE ANSWER THE FOLLOWING QUESTIONS ABOUT THE VESUB SYSTEM

(please circle the response that most closely matches your assessment)

1. The VESUB system provides a positive learning experience.
strongly agree   agree   neutral   disagree   strongly disagree

2. Training with VESUB will increase a trainee's confidence in his ship handling skills.
strongly agree   agree   neutral   disagree   strongly disagree

3. VESUB should be used for introductory ship handling training.
strongly agree   agree   neutral   disagree   strongly disagree

4. VESUB should be used for refresher training for ship handling skills.
strongly agree   agree   neutral   disagree   strongly disagree

5. VESUB should only be used in classroom (shore-based training).
strongly agree   agree   neutral   disagree   strongly disagree

6. VESUB should be installed on submarines for mission rehearsal and refresher training.
strongly agree   agree   neutral   disagree   strongly disagree

7. Please provide any additional suggestions that would improve the realism, performance or training effectiveness of VESUB. (Please continue on the back if necessary.)

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APPENDIX I

VESUB TEE SCENARIO SCRIPT (INBOUND FIRST)

PREBRIEF

VESUB: Virtual Environment for Submarine OOD Ship Handling Training. VESUB is a Research & Development Technology Demonstration Project. There are several known flaws in the system. We are aware of these and will correct them in the future. We'll point these out to you and coach you through them while you are in the system.

History: This is the fourth and final year of the VESUB project. We began with the development of a feasibility demonstration system that was very simple, but allowed us to obtain inputs from fleet experts on the features that were required in VESUB. It took about a year to collect and organize all the inputs into a specification for the system. Two years of development have lead to the system you will experience today.

Purpose and organization of the Training Effectiveness Evaluation (TEE): The purpose of the TEE is to demonstrate to the fleet the effectiveness of VE training technologies. Also, to collect reactions and recommendations on how to improve VESUB for operational use and to improve VE technologies in general. Also, we'd like your inputs on how you think VESUB can be used in the training pipeline and how VE technologies can be used in other tasks.

• The TEE will consist of three scenarios. The first scenario will allow you to experience and practice all system capabilities. The second scenario will train you in several harbor ship handling tasks and the third scenario will test your improvement on these tasks.

• Because your experiences might influence other people's performance, please do not talk to anyone about your experiences in VESUB.

• Because VE technologies are new, we have very little data on how people react to them. We'd like you to fill out a series of "Comfort" questionnaires before and after each session in the VESUB. If AT ANY TIME you feel uncomfortable, tell us and we will remove you from the system.

Now, please take a few moments and fill out the background information and the first "comfort" questionnaire.
Do you have any questions?

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events
Scenario 1 - Orientation (Norfolk) (Page 1 of 3)

Event	Instructor Script
1. Pre-brief: **a.** Restate organization of scenarios. **b.** Show trainee the Norfolk Chart and give basic overview of harbor.	• The TEE will consist of 3 scenarios. The first scenario will allow you to experience and practice all system capabilities. The second scenario will train you in several harbor ship handling tasks and the third scenario will test your improvement on these tasks. • VESUB has modeled two databases: Norfolk, VA and Kings Bay, GA. This orientation scenario will take place in Norfolk. The training and testing scenarios will take place in Kings Bay. • Here is the Norfolk chart. You will be located outside pier 10 and will be headed outbound. While you are in the virtual world, you will be able to call up the chart at any time by saying the word "chart."
2. Trainee is shown all equipment: • Bridge Mock-up • Microphone • HMD	The **Bridge Mock-UP** is intended to provide spatial orientation and a safe environment while you are in the virtual world. Fell free to grab the mock-up to stabilize & orient yourself. We've found that side effects from VE can be greatly reduced by touching something in the real world. Also, feel free to move around the bridge to obtain better views. The system senses where you are looking and repaints the scene. •You will be issuing Helm orders through this push-to-talk **microphone**. You will also be able to request info from the Navigator. You must use station IDs & correct phrasing. You also need to acknowledge repeat backs and reports. Just speak in a normal tone with the mic about 2-3 inches from your mouth. If the system doesn't understand you, it will reply Say again, Sir. The instructor may intervene & tell you to ignore the say again if the system is causing the problem. Try not to hesitate in the middle of a command. If you wish to issue commands to other stations or request information from them (e.g., Control, Contact Coordinator) please do not use the mic. Just speak directly to the instr who will play these roles. You may occasionally hear an erroneous report or repeat back (e.g. "on outboard"). Please ignore these reports. At ANY time, please talk to us about the system or scenario (e.g. my CO would ___). You may call up a chart, course card, or binocs by saying those words into the mic. •This is a high resolution **head-mounted display** or HMD. You focus each eye independently with the slide bars on the right and left of the underside. There are 2 fit adjustments: tightness around your head and height of the eyepieces - Try various positions for best fit. Try to keep the HMD level for best fit.
3. Trainee is placed in HMD -- **Go to the Next Page**	

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events
Scenario 1 - Orientation (Norfolk) (Continued) (Page 2 of 3)

Event	Instructor Script
4. Trainee explores virtual world	• Look around the virtual world. You have a complete 360 degree environment. Notice you can see the rudder astern, although you may need to look around obstacles or hang over the side to see it.
5. Go to **UNFREEZE** • Show **Chart** • Show **Course Card** • Show **Binoculars**	• Look to the Starboard side and say the word "Chart." This chart will dynamically change as you move through the harbor. You may toggle the chart on & off by saying "Chart." Please try now. Find the optimal distance to read the chart. If you are too close you will poke your head right through it. • Look to the Port side and say the word "Course card." You may "toggle" the course card on and off at any time by saying "course card." Please try now. • Look into the distance and say the word "binoculars." You now have a 7.5 power magnified view. This is the same power as the binoculars on the submarine bridge. You can "toggle" the binoculars on and off at any time by saying the word "binoculars" into the mic. Grab the HMD as you would real binocs to steady the view. Please toggle the binoculars on and off a couple of times.
6. Show Contacts at Various Ranges Show how the contacts look through binoculars	We'd like to demonstrate how various contacts appear at different distances • (#13) Look at the contact at 180R, 185T. It is a tug with sand barge at a range of 1600yds. It has a S45 AOB. Now turn on the binoculars • (#6) Look at the contact at 237R, 242T. It is a sailboat at a range of 2500yds, with a S30 AOB. Now turn on the binocs. • (#4) 281R, 286T: Cabin Cruiser, 2100yds, P75 AOB • (#15) 013R, 018T: Fishing Trawler, 2100yds, P135 AOB • (#17)348R, 363T: Black Container Ship, 4800yds, S90 AOB • (#18) 308R, 313T: Blue Container Ship, 4600yds, P23 AOB
7. Show different visibility conditions and time of day	We'd like to show you how the system represents different levels of visibility. You are now in unlimited vis. We'll make it foggy with 2nm visibility. Now, 1nm.....5nm • Here's how it looks with rain approaching & 10nm vis. • You are now at 1030. Here's what different times of day look like (0630, 1200, 2300)
8. Ask Trainee to look at navigation aids and find them on the chart	We'd like you to find several navigation aids & then locate them on the chart. • First, look at the buoy #2 located at 342R. Try the binoculars. Now, try to find it on the chart. • Look at Day beacon ART #8 located at 211R. binoc chart • Please look at Sewell's Pt. Tower located at 043 true. Try binoculars. Now try to find it on the Chart
Go to the Next Page	

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events
Scenario 1 - Orientation (Norfolk) (Continued) (Page 3 of 3)

Event	Instructor Script
9. Ask trainee to issue speed orders	• Try several speed commands. Remember to use station identifiers and to acknowledge the reports. • Ahd 1/3; All Back emergency; All stop; Ahd 2/3
10. Ask trainee to issue several rudder commands	• Try several rudder commands. Remember to use station identifiers and to acknowledge the reports. • Large rudder orders will turn you quickly and slow your headway - small rudder orders will have only limited effect. • The standard rudder for executing turns in our navplan is 15 degrees right or left. • Try some rudder commands now. Remember to visually site the rudder position astern as well as the indicator on the bridge suitcase. • Right 15 degs rudder; Shift your rudder; Steady course 004
11. Show Channel Boundaries and Centerline	• Here are two instructional tools to help the trainee understand his position in the channel. We can highlight the channel boundaries, like this. We can also highlight the centerline, like this. They can be removed, like this.
12. Demonstrate Nav reports	• You will be able to receive information from the Navigator, either produced by the system or the instructor. You can also request information from the Nav with the microphone. • Here's some examples of the information the system can provide. (Distance off track; Course to regain track; Distance to next turn; Next course) • Now, try to ask the Navigator for "distance to NEXT turn"
13. Have trainee make a turn after Nav marks it	Please get underway at ahead 2/3. When you hear the navigator mark the turn, give the appropriate helm order and next course.
14. Ask if he has any questions	Do you have any questions about the system?
Orientation Scenario Ends	Please fill out the second comfort questionnaire

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events
Scenario 2 - Training (Kings Bay Inbound)
Prebrief

In this scenario you will be in a 726 Trident on an inbound course into Kings Bay, GA. Let's take a look at the chart. You enter from the Southeast (not shown on this chart) on Trident Range. Then you turn west onto Entrance Channel, which is protected by jetties and breakwaters that will limit wave height and cross currents. Set & drift on the Entrance Channel will typically be east and west based on tides & currents. Some of the major geographic features of the harbor include: Cumberland Island Sound, ST Mary's and Amelia Rivers all of which will cause currents that will affect your ship, Cumberland Island (served by a Ferry from ST Mary's), and Amelia Island, with FT Clinch on its northern shore. All of the channel legs of this harbor are supported by range markers, either astern, forward, or both. For example, Range "A" has range markers both astern and forward. Other traffic in the harbor may include: coastal merchants going to the paper mills and Amelia Island, fishermen, pleasure craft, and other Navy traffic.

For this scenario:

- Visibility is unlimited
- You are at Flood Tide and currents will be representative of those in Kings Bay
- All Navplan course changes will be based on a 15 degree rudder and a speed of 12 knots
- Total time for the scenario is about 35 minutes
- Red and yellow soundings are set at 3 and 5 feet, respectively
- You may encounter typical traffic like in Kings Bay
- Follow standard inland rules of the road.
- Additionally, you will be expected to abide by harbor directives provided by your Navigator. For example, be sure to slow own ship when passing small boats
- Permission to enter port has already been obtained
- You will be berthed at Trident Refit Wharf #1

Take a few moments to review the chart and course card. You will begin somewhere on the Entrance range. Remember, you will be able to call up the chart and a course card like this from the bridge.

- When we ask you to report a contact, please give a detailed report, including: type of contact, range, bearing, AOB, and your concern about the contact.
- Any Questions? Let's go to the bridge mock-up.

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events
Scenario 2 - Training (Kings Bay Inbound) (page 1 of 8)

Event	Time	Component	Instructor Script
1. Own ship is placed on Entrance Range, 2000yds from the 1st turn, 50yds right of track. **While in Frozen Mode**	00:00	**1P.** Locating & ID Navigation aids; **2P.** Judging Distance; **2C.** Understanding relationship of visual cues to chart(s)	• As quickly and accurately as possible, tell us where you are now located? • What did you do to determine your location? • What is your distance left or right of track? (if not included above) • How did you determine your distance L/R or track? (if not included above)
2. Instructor Intervention	**00:00**		Your Reported Position was: _______________ Your Actual Position was: _______________ Finding and placing own ship in the geographic field is an event that the OOD will experience each time that he relieves the watch. His first task is to review the chart and become familiar with the environment. Next he surveys the visual scene, looks for key reference points and objects, evaluates these and correlates them to his chart to confirm ship's location. (continue on next page)
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APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events
Scenario 2 - Training (Kings Bay Inbound) (page 2 of 8)

Event	Time	Component	Instructor Script
2. Instructor Intervention (continued)	**00:00**	The two step process that may have better supported your efforts in this task would have been to (1) find and fix the position of at least two nav aids. One near the beam and one forward of your position. Additionally, use of closer navigation aids like buoys and channel markers can be used to provide you with placement along the navigator's track. Next (2) it is necessary to sight one of the stationary ranges that are placed at the head of each leg of this harbor. These ranges will provide you with an accurate position in relation to the center of the channel. The range can tell you when you are right, left, or center in the channel. You can further verify positions right or left of track by marking your distance between buoys as you pass through port and starboard pairs, however, these are not always positioned in this manner. Take a look at the following navigation aids in the visual scene (see list that he didn't use from data collection form).	
3. Trainee is asked to report all visible contacts.	**00:00**	**2P.** Judging distance **4P.** ID & avoid obstacles **2C.** Understanding Size/Range & AOB **7C.** Prioritize contacts	Please report all visible contacts. For NOW if you want binocular view, ask the instructor. This is also true for "Chart." After we start the scenario, you will be able to obtain binocular view or chart by saying "binoculars" or "chart" into the microphone.
4. Instructor Intervention		During this event you were asked to find and evaluate all contacts. As an OOD you will need to be cognizant of all contact traffic & maintain a mental picture of the relationship of these contacts to own ship. It is important that you find and evaluate each contact for bearing, range, classification, AOB, and concern that you may have for own ship's safety based on their position in the harbor. More complex tasks, such as determining CPA and Rules of the Road all begin with this first analysis. (go to next page)	
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APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events
Scenario 2 - Training (Kings Bay Inbound) (page 3 of 8)

Event	Time	Component	Instructor Script
4. Instructor Intervention (continued)		Of our contacts you found ____ of _____. The actual contacts were: (use data collection form) Your reported contacts were: (use data collection form)	
5. • Give trainee the mic • Go to **RUN Mode**	00:00		• When we go to run mode, the first thing you hear will be a report from the Navigator. • Here is the microphone. • **UNFREEZE** - The scenario is now running
6. Report from Navigator:	00:02	**8P.** Detecting comms.	• Instructor initiates reports from the Nav. **USE SYSTEM.** • distance from track • recommended course • recommended speed • sounding • set & drift • distance to turn • next course
7. Trainee orders ship to get underway and adjusts course	**00:30**	**10C.** Correctly using ship's systems; **12C.** Effective communication	**Instructor says,** "Recommend you Make turns for 12 knots"
8. Man Overboard (trainee hears report from lookout played by instructor)	**02:30**	**8P.** Detecting comms. **11C.** Taking corrective actions **12C.** Effective comms.	• "Officer of the Deck, Man Overboard Port Side"
9. Maneuvering (Instructor) reports:	02:40	**8P.** Detecting comms.	• "Bridge, Maneuvering. Shaft is stopped and locked"
Go to Next Page			

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events (Continued)
Scenario 2 - Training (Kings Bay Inbound) (Continued - page 4 of 8)

<table>
<tr><th>Event</th><th>Time</th><th>Component</th><th>Instructor Script</th></tr>
<tr><td>10. Report from Control (instructor) - Tug is picking up man overboard</td><td>04:00</td><td>8P. Detecting comms.</td><td>•“Bridge, Navigator. Have contacted C-tractor to retrieve man overboard. C-tractor agrees to take man overboard retrieval responsibilities. Recommend returning to base course 268 at ahead 2/3”</td></tr>
<tr><td>11. Trainee gets ship underway again</td><td>02:50</td><td>11C. Taking corrective actions
12C. Effective comms.</td><td></td></tr>
<tr><td>12. Instructor Intervention
Go to FREEZE</td><td colspan="3">The most important action that the OOD may take on the surface is that of saving the life of a man who has fallen overboard. The ship’s control party has several immediate actions that must be carried out in this casualty, and it is the responsibility of the OOD to ensure that they have been accomplished. He does this through issuing backup orders and through verification of each step.
If the victim has survived the fall into the channel he faces an immediate danger from the ship’s control surfaces and the screw. The OOD takes steps to stop the shaft, so that the blades of the screw will not be turning should they make contact with the man, and to swing the ship away from the man.
Turning the ship is accomplished by putting a full rudder on in the direction of the man; that is, if he has fallen off of the starboard side the ship is turned with right full rudder and left full rudder for the port side.
Your actions could have been more effective if you had:
1. ___ , 2. _____ , 3. _______ , 4. ______
If your position becomes dangerous and you need to put on a backing bell, you need to sound 3 whistles for astern propulsion.
Additionally, you should have given consideration to retrieval of the victim. Using your bridge to bridge radio or having the Navigator communicate with the tug to arrange for a personnel pickup would have allowed you to continue along your track while taking care of your crew member.</td></tr>
<tr><td>Go to Next Page</td><td></td><td></td><td></td></tr>
</table>

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events (Continued)
Scenario 2 - Training (Kings Bay Inbound) (Continued - page 5 of 8)

Event	Time	Component	Instructor Script
13. Go to UNFREEZE Trainee gets ship underway again (Trainee may try to correct ship's position. Should as a minimum, evaluate position and ask Nav for backup)	**04:15**	**10C.** Correct operation of ship's systems **12C.** Effective comms.	• (system) "Bridge, Navigator. Recommend all ahead standard. • (system) "Bridge, Navigator. Recommend xxx to regain track" • (Instructor) "B, N. Recommend you make turns for 12 knots"
14. Trainee commands turn to **Range A** after Nav marks turn Course : **294**	**07:30**	**10C.** Correct operation of ship's systems **12C.** Effective comms.	
15. Nav reports **incorrect** position and **incorrect** course to regain track. After steady on 294. (Left when Right or Right when Left)	**08:15**	**11C.** When & how to take corrective actions **12C.** Effective comms.	Instructor says: • If Center - hold you left of track. Recommend right to 290 to regain track • If left - hold you right of track - recommend R 290 • If right - hold you left of track - recommend L 298
16. Instructor Intervention	We've just given you an incorrect report from the Navigator. This is not to play games, but to point out that the OOD is in charge and must always determine if other people have made a mistake.		
17. Trainee commands turn to **Range A-1** after Nav Marks Turn Course: **302.5**	**12:40**	**12C.** Effective comms.	
Go to the Next Page			

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events (Continued)
Scenario 2 - Training (Kings Bay Inbound)(Continued - page 6 of 8)

Event	Time	Component	Instructor Script
18. Nav reports **correct** information (short report) After steady on 302			System Generates: • distance to turn • next course • distance from track
19. Trainee commands turn to **Range A-2** after Nav Marks Turn Course: **331.5**			
20. Navigator short report (after steady on 331)			System Generates: • distance to turn • next course • distance from track
21. Trainee commands turn to **Range B** after Nav Marks Turn Course: **350**			
22. Navigator short report (after steady on 350)			System Generates: • distance to turn • next course • distance from track
23. Ferry becomes visible (possible).	**15:30**	**4P.** ID & avoid obstacles **7C.** Prioritize contacts **12C.** Effective comms.	
24. Trainee commands turn to **Range C** after Nav Marks Turn Course: **004**	**17:30**	**12C.** Effective comms.	
25. Navigator FULL report - (after steady on 004)			System Generates • distance from track • recommended course • recommended speed • sounding • set & drift • distance to turn • next course
Go to the Next Page			

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events (Continued)
Scenario 2 - Training (Kings Bay Inbound)(Continued - page 7 of 8)

Event	Time	Component	Instructor Script
26. Contact Coordinator report (if not requested by now)			Instructor: "Bridge, Contact Coordinator. Hold contact at xxx. Appears to be a ferry boat. Etc
27. OOD maneuvers own ship to right for P to P passage. Instructor controls Ferry for Port-to-port passage	**20:00**		
28. Trainee increases speed	21:00		
29. Go to **FREEZE** Instructor Intervention		During crossing situations like you just encountered the OOD should: 1) Evaluate the relative motion of contacts to determine if of concern, or will affect own ship's progress along the track You _____. 2) Communicate with other vessels to determine their intended actions. You ____. 3) Slow the ship's headway when he will hazard another vessel. You ______.4) Maneuver to split the channel when necessary. You ____. 5) Report to the Commanding Officer all contacts of concern per the CO's standing orders. These actions will often be done simultaneously and are subject to the OOD's understanding of ship's position and contact actions. One often overlooked resource in contact management is the chart. The OOD should evaluate the contacts that he holds and refer to the chart to determine what constraints they are subject to as they move along the channel. This will help him to sort out their impact on his transit.	
30. Yellow sounding	23:30		"Bridge, Navigator. Yellow sounding, 4ft"
31. Trainee commands to regain speed and course			
Go to the Next Page			

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events (Continued)
Scenario 2 - Training (Kings Bay Inbound)(Continued - page 8 of 8)

Event	Time	Component	Instructor Script
32. Instructor (Nav) gives info. if trainee does not request within 30 secs.	24:00		
33. Go to FREEZE. Instructor Intervention	In the case of a sounding that does not match with charted water depth the nav party will try to confirm the sounding & fix the position of the ship. A yellow sounding is a trip point, set by the navigator and approved by the CO, that indicates that the ship may be standing into danger. It requires OOD to act aggressively to place ship on safest course & heading into safe water. To review the required actions, the OOD should: • Slow the ship's headway. You: Did / Didn't • Confirm the direction to good or best water. You: Did / Didn't • Maneuver to seek center channel or best water when possible. You: Did / Didn't • Fix the ship's position (Nav team will do automatically). You: Did / Didn't • Sight the range ahead or astern as available. You: Did / Didn't • Report to the CAPT the status of the sounding and his actions to properly and safely position the ship. You: Did / Didn't These actions will often be done simultaneously & are subject to the OOD's understanding of ship's position when the yellow sounding was gained.		
34. Go to UNFREEZE. Trainee increases speed & sets new course.	24:30		
35. Scenario Ends	25:00		

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events
Scenario 3 - Testing (Kings Bay Outbound)
Prebrief

In this scenario you will be in a 726 Trident on an outbound course from Kings Bay. Let's take a look at the chart. Kings Bay Naval facility is protected to sea by Crab Island, a man-made island from the dredging of the harbor. As you proceed outbound, you travel through Cumberland Sound. You intersect St. Mary's and Amelia Rivers, which produce currents that will affect your ship due to set & drift. The port includes maintenance piers, Explosive Handling Wharves (large, yellowish buildings), and a dry dock. Warrior Reach area includes a Magnetic Silencing Facility (MSF) and degaussing range and may have large vessels including other warships. All of the legs of the channel include range markers either astern, forward, or both. For example, Range "D" has ranges astern. Other traffic in the harbor may include: coastal merchants going to the paper mills and Amelia Island, fishermen, pleasure craft, and other Navy traffic.

For this scenario:

- Visibility is unlimited
- You are at Ebb Tide and currents will be representative of those in Kings Bay
- All Navplan course changes will be based on 15 degree rudder and a speed of 12 knots
- Total time for the scenario is about 35 minutes
- Red and yellow soundings are set at 3 and 5 feet, respectively
- You may encounter typical traffic that could be seen in Kings Bay
- Follow standard inland rules of the road.
- Additionally, you will be expected to abide by harbor directives provided by your Navigator. For example, be sure to slow own ship when passing small boats

Now, take a few moments to review the chart and course card. Some of the major geographic features include: the base and the facilities already mentioned, Cumberland Island (which is served by a Ferry from ST Mary's), and Amelia Island, with Ft Clinch on its northern shore. You will begin somewhere on Range "D". Remember, you will be able to call up the chart and a course card like this from the bridge.

- When we ask you to report a contact, please give a detailed report including: range, bearing, AOB, and your concern about the contact.

Any Questions? Let's go to the bridge mock-up.

APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events
Scenario 3 - Testing (Kings Bay Outbound)(page 1 of 4)

Event	Time	Component	Instructor Script
1. Sub is placed on **Range "E"**, 800yds from the intersection of **Range "D"**, 50yds right of track. Heading: 152 **System in Frozen Mode**	**0:00**	**1P.** Locating & ID Navigation aids; **2P.** Judging Distance; **2C.** Understanding relationship of visual cues to chart(s)	• As quickly and accurately as possible tell us where you are now located? • What did you use to determine your location? • What is your distance left or right of track? (if not included above) • How did you determine your distance L/R of track? (if not included above)
2. Trainee is asked to report all visible contacts.	**0:00**	**7C.** Prioritize contacts; **2P.** Judging distance	Please report all visible contacts. For NOW if you want binocular view, ask the instructor. After we start the scenario, you will be able to obtain binoc view by saying "binoculars" into the microphone.
3. Go to Run			
4. Trainee receives FULL report from the Navigator	0:10	**8P.** Detecting comms.	• Instructor initiates reports from the Nav: USE SYSTEM • distance from track • recommended course • recommended speed • sounding • set & drift • distance to turn • next course
5. Trainee orders ship to get underway and adjusts course	**0:30**	**10C.** Correctly using ship's systems; **12C.** Effective communication	Instructor: "Bridge, Navigator. Recommend you make turns for 12 knots"
6. Trainee commands turn to Range D after Nav marks turn	**2:00**	**12C.** Effective communication	
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APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events (Continued)
Scenario 3 - Testing (Kings Bay Outbound)(Continued - page 2 of 4)

Event	Time	Component	Instructor Script
7. Trainee orders steady on recommended course (171)	**2:30**	**10C.** Correctly using ship's systems; **12C.** Effective communication	
8. FULL Navigator Report AFTER STEADY ON 171	**3:00**	**8P.** Detecting communications	System generated Nav report: • distance from track • recommended course • recommended speed • sounding • set & drift • distance to turn • next course
9. Man Overboard (trainee hears report from lookout played by instructor)	**5:00**	**8P.** Detecting comms. **11C.** Taking corrective actions **12C.** Effective comms.	"OOD, Lookout. Man overboard, port side."
10. Report from Control (instructor)	**6:00**	**8P.** Detecting comms.	• Instructor says "Bridge, Navigator. Have contacted C-Tractor. He has agreed to recover man overboard. Recommend returning to base course 171 at ahead 2/3"
11. Trainee gets ship underway again	**7:00**	**10C.** Correct operation of ship's systems **12C.** Effective comms.	
12. Nav reports **incorrect** position and **incorrect** course to regain track. (Left when Right or Right when Left)	**8:00**	**11C.** When & how to take corrective actions **12C.** Effective comms.	Instructor says: • If center - "Hold you left of track. Recommend coming right to 180 to regain track. • If left - hold you right of track. Recommend coming R 192 • If right - hold you left of track. Recommend 192
13. Nav reports **correct** information (e.g., position)	8:15		
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APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events (Continued)
Scenario 3 - Testing (Kings Bay Outbound)(Continued - page 3 of 4)

Event	Time	Component	Instructor Script
14. Trainee commands turn to **Range C** Course: 184	12:00	**12C.** Effective comms.	
15. FULL Nav report (after steady on 184)		**8P.** Detecting comms.	System generated Nav report: • distance from track • recommended course • recommended speed • sounding • set & drift • distance to turn • next course
16. Trainee sees Ferry ahead	13:00	**5C.** Rules of Road **12C.** Effective comms.	
17. Instructor controls Ferry for Port-to-port passage	15:00		
18. Trainee gives commands to make port-to-port passage		**5C.** Rules of Road **12C.** Effective comms.	
19. Trainee increases speed	16:30		
20. Trainee commands turn to **Range B** Course: **170**	19:00	**12C.** Effective comms.	
21. SHORT Nav Report (after steady on 170)		**8P.** Detecting comms.	System Generates: • distance to turn • next course • distance from track
22. Trainee commands turn to **Range A-2** Course: **151.5**		**12C.** Effective comms.	
23. SHORT Navigator Report (after steady on 151)		**8P.** Detecting comms.	System Generates: • distance to turn • next course • distance from track
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APPENDIX I: VESUB TEE SCENARIO SCRIPT (INBOUND FIRST) (Continued)

VESUB TEE Scenario Events (Continued)
Scenario 3 - Testing (Kings Bay Outbound) (Continued - page 4 of 4)

Event	Time	Component	Instructor Script
24. Trainee commands turn to **Range A-1** after Nav Marks Turn Course: **122.5**	22:00	**12C.** Effective comms.	
25. SHORT Navigator Report (after steady on 122)		**8P.** Detecting comms.	System Generates: • distance to turn • next course • distance from track
26. Trainee commands turn to **Range A** after Nav Marks Turn Course: **114**	24:00	**12C.** Effective comms.	
27. FULL Navigator report (after steady on 114)		**8P.** Detecting comms.	System generated Nav report: • distance from track • recommended course • recommended speed • sounding • set & drift • distance to turn • next course
28. Yellow Sounding - trainee must take correct actions	25:30	**8P.** Detecting comms. **11C.** Taking corrective actions **12C.** Effective comms.	
29. Trainee increases speed	26:30	**12C.** Effective comms.	
Scenario Ends			

APPENDIX J

VESUB TEE PERFORMANCE DATA COLLECTION FORMS

Scenario 2 - Training (Kings Bay Inbound) (page 1 of 11)

Participant #: G-Groton, CT

Event	Time	Performance Measure
1. Own ship is placed on Entrance Range, 2000yds from the 1st turn, 25yds right of track. **While in Frozen Mode** • Trainee is asked to give location.- **record reported position.** • Trainee is asked how he determined location.- **record all info used.**	00:00	**Left/Right of Track: (POSACRS1)** • Reported Position (Right or Left of Track): ________ • Actual Position (Right or left of Track): ________ • Difference: Reported - Actual (POSACRS1): ________ **Along Track: (POSALNG1: SAT = within 200 yds of actual position)** • Reported Position Along Track: (SAT=(1)/UNSAT=(0) ________ • Navigation aids used (check all that apply): • Beacon "E" ________ • Entrance Range Front________ • Beacon "F" ________ • Entrance Range Rear ________ • Beacon "N" ________ • Ft Clinch Front ________ • Beacon "S" ________ • Ft Clinch Rear ________ • Buoy "D" ________ • Ft Clinch Flagpole ________ • 4 Yellow Buoys ________ • Amelia Island ________ • Buoy "24"(red) ________ • Breakwaters ________ • Buoy"25"(green)________
2. Instructor Intervention	00:00	
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Notes:

POSALNG1: * SAT = within 200 yds of actual position

Scenario 2 - Training (Kings Bay Inbound) (page 2 of 11)

Event	Time	Performance Measure													
3. Trainee is asked to report all visible contacts.	00:00	Actual Positions						Reported Positions							
		Cnt	TBrg	RBrg	Rg	AOB	Y/N	Cnt	Response	TBrg	RBrg	Rg	AOB	Y/N	
		1Tug	073	164	50	P20	Y	1Tug	____	____	____	____	____	____	
		7Cbn	117	209	5250	P35	N	7Cbn	____	____	____	____	____	____	
		8Cbn	088	180	6650	0	N	8Cbn	____	____	____	____	____	____	
		11Ctl	007	099	2050	S150	N	11Ctl	____	____	____	____	____	____	
		3Net	278	010	2420	0	Y	3Net	____	____	____	____	____	____	
		6Slbt	276	008	5450	P15	Y	6Slbt	____	____	____	____	____	____	
4. Instructor Intervention		Contacts :Found: ______ Actual : ______ (ratio found/actual = CNTFND1) Contact Concern: #IDed as concern/# possible of concern (CNTCON1):________ (CNTCON1 = ratio of items reported as a concern / 3)													
Go to Next Page															

APPENDIX J: VESUB TEE PERFORMANCE DATA COLLECTION FORMS (Continued)

Scenario 2 - Training (Kings Bay Inbound) (page 3 of 11)

Event	Time	Performance Measure
5. • Give trainee the mic	00:00	
6. Report from Navigator:	00:02	• Acknowledge Reports? (Y/N) ______
7. Trainee orders ship to get underway and adjusts course • "Helm, Bridge. All ahead standard" • "Helm, Bridge. Come left to 266"	00:30	• Correct commands issued to get underway? (Y/N) ________ (CMDUNW1: ________) • "Helm, Bridge. All ahead 2/3" ________ • "Helm, Bridge. Steady course 266" ________ • Visually check rudder? (Y/N) ________ • Visually check ranges? (Y/N) ________ • Visually check bridge suitcase? (Y/N) ________ • Number of "say agains" • No Station ID ________ • Improper Phraseology ________ • Hesitation ________ Total "Say Agains" ________ • Garbled Speech ________ • System Fault ________ • Number repeated reports (failures to acknowledge) _______
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Notes:

CMDUNW1 = ratio of # correct commands given to get ship underway / total # possible correct commands to get ship underway (= ratio of # correct commands given to get ship underway / 6)

Scenario 2 - Training (Kings Bay Inbound) (page 4 of 11)

Event	Time	Performance Measure
8. Man Overboard (trainee hears report from lookout played by instructor) • "Helm, Bridge. All stop." • "Maneuvering, Bridge. Stop and lock the shaft" • "Helm, Bridge. "Right (left) full rudder.	02:30	**Start stop watch after "on port side!"** • Time to give command: 30 sec max (MOBTIME1) ________ • Number of correct actions: (Time to give command: 30 sec max): ________ •All Stop ________ •Stop and lock the shaft ________ •Left Full Rudder ________ •Communicated Casualty to Ship (Y/N): ________ MOBCMDS1: ________ • Visually check rudder? (Y/N) _______ • Visually check ranges? (Y/N) _______ • Visually check bridge suitcase? (Y/N) _______ • Contact Tug (Y/N) _______ • Number of "say agains" • No Station ID ________ • Improper Phrase ________ • Hesitation ________ Total "Say Agains" ________ • Garbled Speech ________ • System Fault ________ • Number of repeated reports (failures to acknowledge) _______
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Notes:

MOBTIME1 = time to begin issuing commands during man overboard event
MOBCMDS1 = # correct commands given during man overboard event

APPENDIX J: VESUB TEE PERFORMANCE DATA COLLECTION FORMS (Continued)

Scenario 2 - Training (Kings Bay Inbound) (Continued - page 5 of 11)

Event	Time	Performance Measure
9. Maneuvering (Instructor) reports:	02:40	• Acknowledge report? (Y/N) _______
10. Report from control (instructor) - Tug is picking up man overboard		• Acknowledge report? (Y/N) _______
11. Trainee gets ship underway again (Trainee may try to correct ship's position. Should as a minimum, evaluate position and ask Nav for backup)	02:50	• Correct command (Y/N) • "Helm Bridge. All ahead 2/3" (Y/N) _______ • "Helm Bridge. Steady Course 266" (Y/N) _______ • Visually check rudder? (Y/N) _______ • Visually check ranges? (Y/N) _______ • Visually check bridge suitcase? (Y/N) _______ • Correct commands issued to get underway? (Y/N) _______ (CMDUNW1: _______) • "Helm, Bridge. All ahead 2/3" _______ • "Helm, Bridge. Steady course 266" _______ • Number of repeated reports (failures to acknowledge) _______
12. Instructor Intervention Go to FREEZE		
13. Go to UNFREEZE Trainee gets ship underway again	04:15	
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Scenario 2 - Training (Kings Bay Inbound) (Continued - page 6 of 11)

Event	Time	Performance Measure
14. Trainee commands turn to Range A after Nav marks turn Course 294	07:30	• Marked turn: Early_______ On time_______ Late_______ • Correct command (Y/N) • "Helm, Bridge. Right 15 degrees rudder" _______ • "Helm, Bridge. Steady course 294" _______ • Visually check rudder? (Y/N) _______ • Visually check ranges? (Y/N) _______ • Visually check bridge suitcase? (Y/N) _______ • Number of "say agains" • No Station ID _______ • Improper Phrase _______ • Hesitation _______ Total "Say Agains"_______ • Garbled Speech _______ • System Fault _______ • Number of repeated reports (failures to acknowledge) _______
15. Nav reports incorrect position and incorrect course to regain track. (Left when Right or Right when Left)	08:15	• Recognize Error (e.g. Asks for correction/"say again") (Y/N) _______ • Visually check ranges? (Y/N) _______ • Was error self corrected? (Y/N) _______
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APPENDIX J: VESUB TEE PERFORMANCE DATA COLLECTION FORMS (Continued)

Scenario 2 - Training (Kings Bay Inbound) (Continued - page 7 of 11)

Event	Time	Performance Measure
16. Instructor Intervention		
17. Trainee commands turn to Range A-1 after Nav Marks Turn Course: 302.5	12:40	• Marked turn: Early_____ On time_____ Late_____ • Correct command (Y/N) • "Helm, Bridge. Right 15 degrees rudder" _____ • "Helm, Bridge. Steady course 302" _____ • Visually check rudder? (Y/N) _____ • Visually check ranges? (Y/N) _____ • Visually check bridge suitcase? (Y/N) _____ • Number of "say agains" • No Station ID _____ • Improper Phrase _____ • Hesitation _____ Total "Say Agains"_____ • Garbled Speech _____ • System Fault _____ • Number of repeated reports (failures to acknowledge) _____
18. Nav reports correct information (short report) after steady on 302		• Acknowledge report? (Y/N) _____
19. Trainee commands turn to Range A-2 after Nav Marks Turn Course: 331.5		• Marked turn: Early_____ On time_____ Late_____ • Correct command (Y/N) • "Helm, Bridge. Right 15 degrees rudder" _____ • "Helm, Bridge. Steady course 331" _____ • Visually check rudder? (Y/N) _____ • Visually check ranges? (Y/N) _____ • Visually check bridge suitcase? (Y/N) _____ • Number of "say agains" • No Station ID _____ • Improper Phrase _____ • Hesitation _____ Total "Say Agains"_____ • Garbled Speech _____ • System Fault _____ • Number of repeated reports (failures to acknowledge) _____
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Scenario 2 - Training (Kings Bay Inbound) (Continued - page 8 of 11)

Event	Time	Performance Measure
20. Navigator Short Report (after steady on 331)		• Acknowledge report? (Y/N) _____
21.Trainee commands turn to Range B after Nav Marks Turn Course: 350		• Marked turn: Early_____ On time_____ Late_____ • Correct command (Y/N) • "Helm, Bridge. Right 15 degrees rudder" _____ • "Helm, Bridge. Steady course 350" _____ • Visually check rudder? (Y/N) _____ • Visually check ranges? (Y/N) _____ • Visually check bridge suitcase? (Y/N) _____ • Number of "say agains" • No Station ID _____ • Improper Phrase _____ • Hesitation _____ Total "Say Agains"_____ • Garbled Speech _____ • System Fault _____ • Number of repeated reports (failures to acknowledge) _____
22. Navigator short report (after steady on 350)		• Acknowledge report? (Y/N) _____
23. Ferry Becomes visible (possible)	15:30	Request report from Contact Coordinator (Y/N): _____ Reported Ferry (Y/N): _____ Asks for Bridge to Bridge communications (Y/N): _____
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APPENDIX J: VESUB TEE PERFORMANCE DATA COLLECTION FORMS (Continued)

Scenario 2 - Training (Kings Bay Inbound) (Continued - page 9 of 11)

Event	Time	Performance Measure
24. Trainee commands turn to Range C after Nav Marks Turn Course: 004	17:30	• Marked turn: Early______ On time______ Late______ • Correct command (Y/N) • "Helm, Bridge. Right 15 degrees rudder" ______ • "Helm, Bridge. Steady course 004" ______ • Visually check rudder? (Y/N) ______ • Visually check ranges? (Y/N) ______ • Visually check bridge suitcase? (Y/N) ______ • Number of "say agains" • No Station ID ______ • Improper Phrase ______ • Hesitation ______ Total "Say Agains"______ • Garbled Speech ______ • System Fault ______ • Number of repeated reports (failures to acknowledge) ______
25. Navigator Full report (after steady on 004		• Acknowledge report? (Y/N) ______
26. Contact Coordinator Report **Nav Report**		• Acknowledge report? (Y/N) ______
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Scenario 2 - Training (Kings Bay Inbound) (Continued - page 10 of 11)

Event	Time	Performance Measure
27. **OOD maneuvers own ship to right for P to P passage.** Instructor controls Ferry for Port-to-port passage	20:00	• Moves own ship to right (Y/N) ______ • Slows own ship when passing? (Y/N) ______
28. Trainee increases speed	21:00	• Correct commands issued to get underway? (Y/N)______ (CMDUNW1:______) • "Helm, Bridge. All ahead 2/3" ______ • "Helm, Bridge. Steady course 004" ______ • Number of "say agains" • No Station ID ______ • Improper Phrase ______ • Hesitation ______ Total "Say Agains"______ • Garbled Speech ______ • System Fault ______
29. Go to **FREEZE** **Instructor Intervention**		
30. Yellow sounding	23:30	
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APPENDIX J: VESUB TEE PERFORMANCE DATA COLLECTION FORMS (Continued)

Scenario 2 - Training (Kings Bay Inbound)(Continued - page 11 of 11)

Event	Time	Performance Measure
31. Trainee commands		• Time to Give Command _______ • Slows own ship? (Y/N) _______ Example: "Helm, Bridge. All stop" YELWSND1: _________ • Checked ranges? (Y/N) _______ • Fixes ship's position _______ Example: "Navigator, Bridge. What is current position? • Requests backup sounding? (Y/N) _______ Example: "Navigator, Bridge. Report (request) backup sounding" • Requests bearing to best water or center of channel? (Y/N) _______ Example: "Navigator, Bridge. What is the direction to good water?" Example: "Navigator, Bridge. What is the nearest shoal water? • Reports to CAPT? (Y/N) _______
32. Instructor (Nav) gives info. if trainee does not request within 30 secs.	24:00	• Does Instructor have to provide info? (Y/N) _______
33. Go to **FREEZE.** **Instructor Intervention**		
34. Go to **UNFREEZE.** Trainee increases speed & sets new course.	24:30	• Order bell_______ / course ________ to regain control of vessel • Number of "say agains" • No Station ID _______ • Improper Phrase _______ • Hesitation _______ • Garbled Speech _______ • System Fault _______ Total "Say Agains"_______
35. Scenario Ends	25:00	

Notes: **YELWSND1** = # correct commands given during yellow sounding event

Scenario 3 - Testing (Kings Bay Outbound)(page 1 of 10)

Event	Time	Performance Measure
1. Sub is placed on **Range "E"**, 800yds from the intersection of **Range "D"**, 50yds right of track. Heading: 152 **While in Frozen Mode** • Trainee is asked, **"Where are you?"** He answers - **record reported position.** • Trainee is asked, **"What information did you use to determine your position?"** He answers - **record all info used.**	0:00	**Left/Right of Track: (POSACRS2)** • Reported Position(Right or Left of Track): _______________ • Actual Position (Right or Left of Track): _______________ • **Difference**: Reported - Actual (**POSACRS2**): _______________ **Along Track: (POSALNG2 : SAT = within 200 yds of actual position)** • Reported Position Along Track: (SAT (1)/UNSAT (0))_______________ • **Navigation aids** used (check all that apply): • Buoy 49 _______ • Upper "E" Front_______ • Buoy 50 _______ • Upper "E" Rear _______ • Buoy 51 _______ • Lower "E" Front_______ • Light 50 _______ • Lower "E" Rear _______ • Light 52 _______ • MSF _______ • "D" Front _______ • "D" Rear _______
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Notes: **POSALNG2:** * SAT = within 200 yds of actual position

APPENDIX J: VESUB TEE PERFORMANCE DATA COLLECTION FORMS (Continued)

Scenario 3 - Testing (Kings Bay Outbound) (Continued - page 2 of 10)

Event	Time	Performance Measure	
2. Trainee is asked to report all visible contacts.	0:00	Actual Positions Cnt / Tbrg / Rbrg / Rg / AOB / Y/N 1 Tug 187 034 180 P145 Y 2 Tug 344 192 180 S15 Y 7 CbnCru 166 014 3200 S168 Y 11 YP689 320 167 2200 S20 N 10 sail 065 272 900 P45 N ------------------------------ 12*SSBN* 181 029 300 P175 N	Reported Positions Cnt / Response / TrBrg / RlBrg / Rg / AOB / Y/N 1 Tug ____ ____ ____ ____ ____ ____ 2 Tug ____ ____ ____ ____ ____ ____ 7 CbnCr ____ ____ ____ ____ ____ ____ 11 YP689 ____ ____ ____ ____ ____ ____ 10 sail ____ ____ ____ ____ ____ ____ ------------------------------ 12*SSBN* ____ ____ ____ ____ ____ ____
		# Contacts: Found_____ Actual_____ (ratio found/actual = CNTFND2) Contact Concern: # IDed as concern/# possible of concern (CNTCON2): ________ (CNTCON2 = ratio of items reported as a concern / 3)	
3. Go to RUN Mode	0:00		
Go to the Next Page			

Scenario 3 - Testing (Kings Bay Outbound) (Continued - page 3 of 10)

Event	Time	Performance Measure
4. Trainee receives Full reports from the Navigator	0:10	• Acknowledge report? (Y/N) ______
5. Trainee orders ship to get underway and adjusts course	0:30	• Correct commands issued to get underway? (Y/N) _______ (CMDUNW2:_______) • "Helm, Bridge. All ahead 2/3" _______ • "Helm, Bridge. Come Left to _ _______ • Visually check rudder? (Y/N) _______ • Visually check ranges? (Y/N) _______ • Visually check bridge suitcase? (Y/N) _______ • Number of "say agains" • No Station ID _______ • Improper Phrase _______ • Hesitation _______ Total "Say Agains"_______ • Garbled Speech _______ • System Fault _______ • Number of repeated reports (failures to acknowledge) ______
6. Trainee commands turn to Range D after Nav marks turn, steady on recommended course (171)		• Marked Turn: Early_____ On time _____ Late_____ • "Helm, Bridge. RT 15 degrees rudder" _______ • "Helm, Bridge. Steady course 171" _______ • Visually check rudder? (Y/N) _______ • Visually check ranges? (Y/N) _______ • Visually check bridge suitcase? (Y/N) _______ • Number of "say agains" • No Station ID _______ • Improper Phrase _______ • Hesitation _______ Total "Say Agains"_______ • Garbled Speech _______ • System Fault _______ • Number of repeated reports (failures to acknowledge) ______
7. Trainee orders steady on recommended course (171)	2:00	

Notes: **CMDUND2** = ratio of # correct commands given to get ship underway / total # possible correct commands to get ship underway (= ratio of # correct commands given to get ship underway / 6)

APPENDIX J: VESUB TEE PERFORMANCE DATA COLLECTION FORMS (Continued)

Scenario 3 - Testing (Kings Bay Outbound) (Continued - page 4 of 10)

Event	Time	Performance Measure
8. Full Navigator Report after steady on 171	3:00	• Acknowledge report? (Y/N) ______
9. Man Overboard (trainee hears report from lookout played by instructor) • "Helm, Bridge. All Stop." • "Maneuvering, Bridge. Stop and lock the shaft." "Helm, Bridge. Left full rudder."	5:00	**Start stop watch after "on port side!"** • Time to give command: 30 sec max (**MOBTIME2**): ______ • Number of correct actions: • All Stop (Y/N): ______ • Stop and lock the shaft (Y/N): ______ • Left Full Rudder (Y/N): ______ • Communicated Casualty to Ship (Y/N): ______ • Visually check rudder? (Y/N) ______ **MOBCMDS2:** ______ • Visually check ranges? (Y/N) ______ • Visually check bridge suitcase? (Y/N) ______ • Contact Tug (Y/N) ______ • Number of "say agains" • No Station ID ______ • Improper Phrase ______ • Hesitation ______ Total "Say Agains" ______ • Garbled Speech ______ • System Fault ______ • Number of repeated reports (failures to acknowledge) ______

Notes:
MOBCMDS2 = # correct commands given during man overboard event
MOBTIME2 = time to begin issuing commands during man overboard event

Scenario 3 - Testing (Kings Bay Outbound) (Continued - page 5 of 10)

Event	Time	Performance Measure
10. Report from Control (instructor) - Tug is picking up man overboard	5:00	• Acknowledge report? (Y/N) ______
11. Trainee gets ship underway again		• Correct command (Y/N) ______ • Correct commands issued to get underway? (Y/N) ______ (**CMDUNW2:** ______) • "Helm, Bridge. All ahead 2/3" ______ • "Helm, Bridge. Steady course 171" ______ • Visually check rudder? (Y/N) ______ • Visually check ranges? (Y/N) ______ • Visually check bridge suitcase? (Y/N) ______ • Number of "say agains" • No Station ID ______ • Improper Phrase ______ • Hesitation ______ Total "Say Agains" ______ • Garbled Speech ______ • System Fault ______ • Number of repeated reports (failures to acknowledge) ______

APPENDIX J: VESUB TEE PERFORMANCE DATA COLLECTION FORMS (Continued)

Scenario 3 - Testing (Kings Bay Outbound) (Continued - page 6 of 10)

Event	Time	Performance Measure
12. Nav reports incorrect position and incorrect course to regain track. (Left when Right or Right when Left)	8:00	• Recognize Error (Asks for correction or "Say Again") (Y/N) ________ • Visually check ranges? (Y/N) ________ • Was error self corrected? (Y/N) ________
13. Nav reports correct information (e.g., position)	8:15	• Acknowledge report? (Y/N) ________
14. Trainee commands turn to Range C after Nav Marks Turn Course: 184		• Marked turn: Early______ On time______ Late______ • Correct command (Y/N) • "Helm, Bridge. Right 15 degrees rudder" ________ • "Helm, Bridge. Steady course 184" ________ • Visually check rudder? (Y/N) ________ • Visually check ranges? (Y/N) ________ • Visually check bridge suitcase? (Y/N) ________ • Number of "say agains" • No Station ID ________ • Improper Phrase ________ • Hesitation ________ Total "Say Agains"________ • Garbled Speech ________ • System Fault ________ • Number of repeated reports (failures to acknowledge) ________
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Scenario 3 - Testing (Kings Bay Outbound) (Page 7 of 10)

Event	Time	Performance Measure
15. Full Nav report (after steady on 184)		• Acknowledge report? (Y/N) ________
16. Trainee sees Ferry ahead	13:00	Request report from contact coordinator (Y/N) ________ • Reports Ferry as a concern (Y/N): ________ • Asks for Bridge to Bridge Communications (Y/N) ________
17. Instructor controls Ferry for Port-to-port passage	15:00	
18. Trainee gives commands to make port-to-port passage		• Moves own ship to right (Y/N) ________ • Slows own ship when passing? (Y/N) ________
19. Trainee increases speed	16:30	Correct Command? (Y/N): __________ "Helm, Bridge. All ahead standard" ________ Returns to base course (Y/N) : ________ • Number of "say agains" • No Station ID ________ • Improper Phrase ________ • Hesitation ________ Total "Say Agains"________ • Garbled Speech ________ • System Fault ________ • Number of repeated reports (failures to acknowledge) ________ • Visually check rudder? (Y/N) ________ • Visually check ranges? (Y/N) ________ • Visually check bridge suitcase? (Y/N) ________
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APPENDIX J: VESUB TEE PERFORMANCE DATA COLLECTION FORMS (Continued)

Scenario 3 - Testing (Kings Bay Outbound) (Continued - page 8 of 10)

Event	Time	Performance Measure
20. Go to UNFREEZE Trainee commands turn to Range B after Nav Marks Turn Course: 170	19:00	• Marked turn: Early______ On time______ Late______ • Correct command (Y/N) • "Helm, Bridge. Left 15 degrees rudder" _______ • "Helm, Bridge. Steady course 170" _______ • Visually check rudder? (Y/N) _______ • Visually check ranges? (Y/N) _______ • Visually check bridge suitcase? (Y/N) _______ • Number of "say agains" • No Station ID _______ • Improper Phrase _______ • Hesitation _______ Total "Say Agains"_______ • Garbled Speech _______ • System Fault _______ • Number of repeated reports (failures to acknowledge) _______
21. Short Navigator Report (after steady on 170)		• Acknowledge report? (Y/N) _______
22. Trainee commands turn to Range A-2 after Nav Marks Turn Course: 151.5		• Marked turn: Early______ On time______ Late______ • Correct command (Y/N) • "Helm, Bridge. Left 15 degrees rudder" _______ • "Helm, Bridge. Steady course 151" _______ • Visually check rudder? (Y/N) _______ • Visually check ranges? (Y/N) _______ • Visually check bridge suitcase? (Y/N) _______ • Number of "say agains" • No Station ID _______ • Improper Phrase _______ • Hesitation _______ Total "Say Agains"_______ • Garbled Speech _______ • System Fault _______ • Number of repeated reports (failures to acknowledge) _______
Go to the Next Page		

Scenario 3 - Testing (Kings Bay Outbound) (Continued - page 9 of 10)

Event	Time	Performance Measure
23. Short Navigator Report (after steady on 151)		• Acknowledge report? (Y/N) _______
24. Trainee commands turn to Range A-1 after Nav Marks Turn Course: 122.5	22:00	• Marked turn: Early______ Ontime______ Late______ • Correct command (Y/N) • "Helm, Bridge. Left 15 degrees rudder" _______ • "Helm, Bridge. Steady course 122" _______ • Visually check rudder? (Y/N) _______ • Visually check ranges? (Y/N) _______ • Visually check bridge suitcase? (Y/N) _______ • Number of "say agains" • No Station ID _______ • Improper Phrase _______ • Hesitation _______ Total "Say Agains"_______ • Garbled Speech _______ • System Fault _______ • Number of repeated reports (failures to acknowledge) _______
25. Short Navigator Report (after steady on 122		• Acknowledge report? (Y/N) _______
26. Trainee commands turn to Range A after Nav Marks Turn Course: 114	24:00	• Marked turn: Early______ On time______ Late______ • Correct command (Y/N) • "Helm, Bridge. Left 15 degrees rudder" _______ • "Helm, Bridge. Steady course 114" _______ • Visually check rudder? (Y/N) _______ • Visually check ranges? (Y/N) _______ • Visually check bridge suitcase? (Y/N) _______ • Number of "say agains" • No Station ID _______ • Improper Phrase _______ • Hesitation _______ Total "Say Agains"_______ • Garbled Speech _______ • System Fault _______ • Number of repeated reports (failures to acknowledge) _______

APPENDIX J: VESUB TEE PERFORMANCE DATA COLLECTION FORMS (Continued)

Scenario 3 - Testing (Kings Bay Outbound) (Continued - page 10 of 10)

Event	Time	Performance Measure
28. Full Navigator Report (after steady on 114		• Acknowledge report? (Y/N) _______
29. Yellow Sounding - trainee must take correct actions	25:00	• Time to give command _______ • Slows own ship? (Y/N) _______ Example: "Helm, Bridge. All stop" YELSND2: _________ • Checked ranges? (Y/N) _______ • Fixes ship's position _______ Example: "Navigator, Bridge. What is current position? • Requests backup sounding? (Y/N) _______ Example: "Navigator, Bridge. Report (request) backup sounding" • Requests bearing to best water or center of channel? (Y/N) _______ Example: "Navigator, Bridge. What is the direction to good water?" Example: "Navigator, Bridge. What is the nearest shoal water? • Reports to CAPT? (Y/N) _______
33. Trainee increases speed	26:00	• Ordered bell? (Y/N) _______ • Ordered Course? (Y/N) _______
34. Instructor Intervention		
35. Scenario Ends		

Notes:

YELWSND2 = # correct commands given during yellow sounding event

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APPENDIX K

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT

Symptom Scores Prior to Orientation Scenario

Ss #	GenDis	Fatigue	HdAche	EyeStrn	DiffFoc	Saliv	Sweat	Nausea
N-1	1	0	0	0	0	0	0	0
N-2	0	0	0	0	1	0	0	0
N-3	0	0	0	0	0	0	0	0
N-4	0	0	0	0	0	0	0	0
N-5	0	0	0	0	0	0	0	0
N-6	0	0	0	0	0	0	0	0
N-7	0	1	0	0	0	0	0	0
N-8	0	0	0	0	0	0	0	0
N-9	0	1	0	0	0	0	1	0
N-10	1	1	1	0	0	0	0	0
N-11	1	1	0	0	0	0	1	0
N-12	0	0	0	0	0	0	0	0
N-13	0	0	0	0	0	0	0	0
N-14	0	0	0	0	0	0	0	0
N-15	0	0	0	0	0	0	0	0
N-16	0	0	0	0	0	0	0	0
N-17	0	0	0	0	0	0	0	0
N-18	0	0	0	0	0	0	0	0
N-19	0	0	0	0	0	0	0	0
N-20	0	0	0	0	0	0	0	0

Note: N = Norfolk; G = Groton
0 = None; 1 = Slight; 2 = Moderate; 3 = Severe

Appendix K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Symptom Scores Prior to Orientation Scenario

Ss #	DifCon	FullHd	BlurVis	Diz(O)	Diz(C)	Vertigo	Stomac	Burping
N-1	0	0	0	0	0	0	0	0
N-2	1	0	1	0	0	0	0	0
N-3	0	0	0	0	0	0	0	0
N-4	0	0	0	0	0	0	0	0
N-5	0	0	0	0	0	0	0	0
N-6	0	0	0	0	0	0	0	0
N-7	0	0	0	0	0	0	0	0
N-8	0	0	0	0	0	0	0	0
N-9	0	0	0	0	0	0	0	0
N-10	0	0	0	0	0	0	0	0
N-11	0	0	0	0	0	0	0	0
N-12	0	0	0	0	0	0	0	0
N-13	0	0	0	0	0	0	0	0
N-14	0	0	0	0	0	0	0	0
N-15	0	0	0	0	0	0	0	0
N-16	0	0	0	0	0	0	0	0
N-17	0	0	0	0	0	0	0	0
N-18	0	0	0	0	0	0	0	0
N-19	0	0	0	0	0	0	0	0
N-20	0	0	0	0	0	0	0	0

Note: N = Norfolk; G = Groton
0 = None; 1 = Slight; 2 = Moderate; 3 = Severe

APPENDIX K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Symptom Scores Prior to Orientation Scenario

Ss #	GenDis	Fatigue	HdAche	EyeStrn	DifFoc	Saliv	Sweat	Nausea
G-1	0	1	0	1	1	0	0	0
G-2	1	0	0	0	0	0	0	0
G-3	0	0	0	0	0	0	0	0
G-4	0	0	0	0	0	0	0	0
G-5	0	2	0	0	1	0	0	0
G-6	0	0	0	0	0	0	0	0
G-7	1	1	1	0	0	0	0	0
G-8	0	0	0	0	0	0	0	0
G-9	1	0	0	0	0	0	0	0
G-10	0	0	0	0	0	1	1	0
G-11	0	0	0	0	0	0	0	0
G-12	0	0	0	0	0	0	0	0
G-13	1	0	0	0	0	0	0	0
G-14	0	0	0	0	0	0	0	0
G-15	0	1	0	0	0	0	0	0
G-16	0	0	0	0	0	0	0	0
G-17	0	0	0	0	0	0	0	0
G-18	0	0	0	0	0	0	0	0
G-19	0	1	0	0	0	0	0	0
G-20	1	1	0	0	0	0	0	0
G-21	0	1	0	0	0	0	1	0
G-22	0	1	0	0	0	0	0	0

Note: N = Norfolk; G = Groton
0 = None; 1 = Slight; 2 = Moderate; 3 = Severe

APPENDIX K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Symptom Scores Prior to Orientation Scenario

Ss #	DifCon	FullHd	BlurVis	Diz(O)	Diz(C)	Vertigo	Stomac	Burping
G-1	0	0	1	0	0	0	0	0
G-2	0	0	0	0	0	0	0	0
G-3	0	0	0	0	0	0	0	0
G-4	0	0	0	0	0	0	0	0
G-5	0	0	0	0	0	0	0	0
G-6	0	0	0	0	0	0	0	0
G-7	0	1	0	0	0	0	0	0
G-8	0	0	0	0	0	0	0	0
G-9	0	1	0	0	0	0	0	0
G-10	0	0	0	0	0	0	1	0
G-11	0	0	0	0	0	0	0	0
G-12	0	0	1	0	0	0	0	0
G-13	0	1	0	0	0	0	0	0
G-14	0	0	0	0	0	0	1	0
G-15	0	0	0	0	0	0	0	0
G-16	0	0	0	0	0	0	0	0
G-17	0	0	0	0	0	0	0	0
G-18	0	0	0	0	0	0	0	0
G-19	1	0	0	0	0	0	0	0
G-20	0	2	0	0	0	0	0	0
G-21	0	0	0	0	0	0	0	0
G-22	0	0	0	0	0	0	0	0

Note: N = Norfolk; G = Groton
0 = None; 1 = Slight; 2 = Moderate; 3 = Severe

APPENDIX K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Transformed Scores Prior to Orientation Scenario

Ss #	Tot "n"	Tot "o"	Tot"d"	"N"	"O"	"D"	Total Score
N-1	0	1	0	0	7.58	0	3.74
N-2	2	3	2	19.08	22.74	27.84	26.18
N-3	0	0	0	0	0	0	0
N-4	0	0	0	0	0	0	0
N-5	0	0	0	0	0	0	0
N-6	0	0	0	0	0	0	0
N-7	0	1	0	0	7.58	0	3.74
N-8	0	0	0	0	0	0	0
N-9	1	1	0	9.54	7.58	0	7.48
N-10	0	3	0	0	22.74	0	11.22
N-11	1	2	0	9.54	15.16	0	11.22
N-12	0	0	0	0	0	0	0
N-13	0	0	0	0	0	0	0
N-14	0	0	0	0	0	0	0
N-15	0	0	0	0	0	0	0
N-16	0	0	0	0	0	0	0
N-17	0	0	0	0	0	0	0
N-18	0	0	0	0	0	0	0
N-19	0	0	0	0	0	0	0
N-20	0	0	0	0	0	0	0

Note: N = Norfolk; G = Groton
"n" = Sum of Symptom Scores on Nausea Subscale
"o" = Sum of Symptom Scores on Oculomotor Subscale
"d" = Sum of Symptom Scores on Disorientation Subscale
"N" = Weighted Nausea Factor Score [(n) x 9.54]
"O" = Weighted Oculomotor Factor Score [(o) x 7.58]
"D" = Weighted Disorientation Factor Score [(d) x 13.92]
Total Score = [(n) + (o) + (d) x 3.74]

APPENDIX K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Transformed Scores Prior to Orientation Scenario

Ss #	Tot "n"	Tot "o"	Tot "d"	"N"	"O"	"D"	Total Score
G-1	0	4	2	0	30.32	27.84	22.44
G-2	0	1	0	0	7.58	0	3.74
G-3	0	0	0	0	0	0	0
G-4	0	0	0	0	0	0	0
G-5	0	3	1	0	22.74	13.92	14.96
G-6	0	0	0	0	0	0	0
G-7	0	3	1	0	22.74	13.92	14.96
G-8	0	0	0	0	0	0	0
G-9	0	1	1	0	7.58	13.92	7.48
G-10	3	0	0	28.62	0	0	11.22
G-11	0	0	0	0	0	0	0
G-12	0	1	1	0	7.58	13.92	7.48
G-13	0	1	1	0	7.58	13.92	7.48
G-14	1	0	0	9.54	0	0	3.74
G-15	0	1	0	0	7.58	0	3.74
G-16	0	0	0	0	0	0	0
G-17	0	0	0	0	0	0	0
G-18	0	0	0	0	0	0	0
G-19	1	2	0	9.54	15.16	0	11.22
G-20	0	2	2	0	15.16	27.84	14.96
G-21	1	1	0	9.54	7.58	0	7.48
G-22	0	1	0	0	7.58	0	3.74

Note: N = Norfolk; G = Groton
"n" = Sum of Symptom Scores on Nausea Subscale
"o" = Sum of Symptom Scores on Oculomotor Subscale
"d" = Sum of Symptom Scores on Disorientation Subscale
"N" = Weighted Nausea Factor Score [(n) x 9.54]
"O" = Weighted Oculomotor Factor Score [(o) x 7.58]
"D" = Weighted Disorientation Factor Score [(d) x 13.92]
Total Score = [(n) + (o) + (d) x 3.74]

APPENDIX K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Symptom Scores After Scenarios

Ss #	GenDis			Fatigue			HdAche			EyeStrn			DiffFoc			Salivate			Sweat			Nausea		
	Scenario			Scenario			Scenario			Scenario			Scenario			Scenario			Scenario			Scenario		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
N-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-2	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
N-3	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1
N-4	1	1	1	0	0	1	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
N-5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
N-6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
N-7	1	2	X	1	0	X	0	0	X	1	1	X	0	1	X	1	3	X	1	2	X	1	2	X
N-8	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-9	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0
N-10	1	1	1	1	1	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
N-11	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-13	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
N-14	1	1	X	0	0	X	1	2	X	1	1	X	2	1	X	0	0	X	1	1	X	0	2	X
N-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
N-16	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
N-17	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
N-18	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
N-19	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-20	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Note: N = Norfolk; G = Groton
0 = None; 1 = Slight; 2 = Moderate; 3 = Severe
X = Subject Dropped from Evaluation

Appendix K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Symptom Scores After Scenarios

Ss #	GenDis			Fatigue			HdAche			EyeStrn			DifFoc			Salivate			Sweat			Nausea		
	Scenario			Scenario			Scenario			Scenario			Scenario			Scenario			Scenario			Scenario		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
G-1	0	1	1	1	1	1	0	0	0	1	1	2	0	1	1	0	0	0	0	0	0	0	0	0
G-2	1	1	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1
G-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-4	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
G-5	0	2	1	2	2	2	1	2	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0
G-6	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
G-7	1	1	1	0	1	1	1	1	0	1	2	0	0	0	0	0	0	0	0	1	0	0	0	0
G-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-9	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
G-10	0	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	0	0	1	1	1	0	0	0
G-11	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	2	1	0	1	1
G-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
G-13	1	1	1	0	1	1	0	0	0	1	1	1	0	0	1	0	0	0	0	1	1	0	0	0
G-14	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
G-15	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
G-16	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-18	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
G-19	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
G-20	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0
G-21	0	1	1	1	1	1	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0
G-22	0	0	0	1	1	1	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0

Note: N = Norfolk; G = Groton
0 = None; 1 = Slight; 2 = Moderate; 3 = Severe

APPENDIX K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Symptom Scores After Scenarios

Ss #	DifCon			FullHd			BlurVis			Diz(O)			Diz(C)			Vertigo			Stomch			Burping		
	Scenario			Scenario			Scenario			Scenario			Scenario			Scenario			Scenario			Scenario		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
N-1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
N-2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-3	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
N-4	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
N-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-7	0	1	X	0	0	X	0	0	X	0	1	X	0	0	X	0	0	X	1	2	X	0	0	X
N-8	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-10	0	0	0	1	1	1	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	1	0	0
N-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-13	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-14	0	1	X	0	0	X	0	0	X	0	0	X	0	0	X	0	0	X	1	1	X	0	1	X
N-15	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-19	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	0	0	1
N-20	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: N = Norfolk; G = Groton
0 = None; 1 = Slight; 2 = Moderate; 3 = Severe
X = Subject Dropped from Evaluation

APPENDIX K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT Continued)

Symptom Scores After Scenarios

Ss #	DifCon			FullHd			BlurVis			Diz(O)			Diz(C)			Vertigo			Stomch			Burping		
	Scenario			Scenario			Scenario			Scenario			Scenario			Scenario			Scenario			Scenario		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
G-1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0
G-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
G-6	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-7	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0
G-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-9	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
G-11	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
G-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-13	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-14	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
G-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-18	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
G-19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
G-20	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
G-21	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: N = Norfolk; G = Groton
0 = None; 1 = Slight; 2 = Moderate; 3 = Severe

APPENDIX K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Transformed Scores After Scenarios

Ss #	Tot"n"			Tot"o"			Tot"d"			"N"			"O"		
	Scenario			Scenario			Scenario			Scenario			Scenario		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
N-1	0	0	1	0	0	1	0	1	0	0	0	9.54	0	0	7.58
N-2	0	0	0	3	1	1	3	0	0	0	0	0	22.74	7.58	7.58
N-3	0	0	1	2	2	1	4	4	4	0	0	9.54	15.16	15.16	7.58
N-4	0	1	0	3	4	5	3	3	1	0	9.54	0	22.74	30.32	37.9
N-5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	7.58
N-6	0	1	0	0	0	0	0	0	0	0	9.54	0	0	0	0
N-7	4	10	0	3	5	0	1	4	X	38.16	95.4	0	22.74	37.9	0
N-8	0	0	0	0	1	1	0	1	1	0	0	0	0	7.58	7.58
N-9	1	1	0	1	1	0	1	1	0	9.54	9.54	0	7.58	7.58	0
N-10	1	0	0	4	3	3	5	2	1	9.54	0	0	30.32	22.74	22.74
N-11	0	0	0	0	0	1	0	0	0	0	0	0	0	0	7.58
N-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-13	0	0	0	3	3	3	2	2	2	0	0	0	22.74	22.74	22.74
N-14	2	6	0	5	6	0	2	3	X	19.08	57.24	0	37.9	45.48	0
N-15	0	1	1	1	0	0	1	0	0	0	9.54	9.54	7.58	0	0
N-16	0	0	0	1	1	2	0	0	0	0	0	0	7.58	7.58	15.16
N-17	0	0	0	1	0	0	1	0	0	0	0	0	7.58	0	0
N-18	0	0	0	1	2	0	0	0	0	0	0	0	7.58	15.16	0
N-19	0	1	2	0	1	0	0	2	0	0	9.54	19.08	0	7.58	0
N-20	0	0	0	2	0	0	2	0	0	0	0	0	15.16	0	0

Note: N = Norfolk; G = Groton
"n" = Sum of Symptom Scores on Nausea Subscale
"o" = Sum of Symptom Scores on Oculomotor Subscale
"d" = Sum of Symptom Scores on Disorientation Subscale
"N" = Weighted Nausea Factor Score [(n) x 9.54]
"O" = Weighted Oculomotor Factor Score [(o) x 7.58]
"D" = Weighted Disorientation Factor Score [(d) x 13.92]
Total Score = [(n) + (o) + (d) x 3.74]
X = Subject Dropped from Evaluation

APPENDIX K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Transformed Scores After Scenarios

Ss #	Tot"n"			Tot"o"			Tot"d"			"N"			"O"		
	Scenario			Scenario			Scenario			Scenario			Scenario		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
G-1	0	0	0	4	5	6	2	2	2	0	0	0	30.32	37.9	45.48
G-2	1	4	1	3	3	1	1	1	1	9.54	38.16	9.54	22.74	22.74	7.58
G-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-4	0	1	0	0	2	2	0	0	0	0	9.54	0	0	15.16	15.16
G-5	0	0	0	4	7	7	0	1	3	0	0	0	30.32	53.06	53.06
G-6	0	1	1	0	3	3	0	0	0	0	9.54	9.54	0	22.74	22.74
G-7	1	3	1	3	5	2	1	1	1	9.54	28.62	9.54	22.74	37.9	15.16
G-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-9	1	1	0	1	1	0	1	1	0	9.54	9.54	0	7.58	7.58	0
G-10	2	2	2	3	1	2	2	0	0	19.08	19.08	19.08	22.74	7.58	15.16
G-11	0	4	2	1	3	1	0	2	2	0	38.16	19.08	7.58	22.74	7.58
G-12	0	1	0	0	0	0	0	0	0	0	9.54	0	0	0	0
G-13	1	1	1	2	3	5	1	1	3	9.54	9.54	9.54	15.16	22.74	37.9
G-14	0	2	0	1	1	1	0	2	0	0	19.08	0	7.58	7.58	7.58
G-15	0	0	0	0	0	1	0	0	0	0	0	0	0	0	7.58
G-16	0	0	0	0	1	1	0	0	0	0	0	0	0	7.58	7.58
G-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G-18	0	0	0	0	3	0	1	3	1	0	0	0	0	22.74	0
G-19	2	3	0	2	1	1	0	0	0	19.08	28.62	0	15.16	7.58	7.58
G-20	1	2	2	0	1	2	1	1	1	9.54	19.08	19.08	0	7.58	15.16
G-21	0	0	0	3	5	6	1	1	2	0	0	0	22.74	37.9	45.48
G-22	0	0	0	3	3	1	1	1	0	0	0	0	22.74	22.74	7.58

Note: N = Norfolk; G = Groton
"n" = Sum of Symptom Scores on Nausea Subscale
"o" = Sum of Symptom Scores on Oculomotor Subscale
"d" = Sum of Symptom Scores on Disorientation Subscale
"N" = Weighted Nausea Factor Score [(n) x 9.54]
"O" = Weighted Oculomotor Factor Score [(o) x 7.58]
"D" = Weighted Disorientation Factor Score [(d) x 13.92]
Total Score = [(n) + (o) + (d) x 3.74]

APPENDIX K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Transformed Scores After Scenarios and Time in HMD

Ss #	"D"			Total Score			Duration (Min.Sec)		
	Scenario 1	2	3	Scenario 1	2	3	Scenario 1	2	3
N-1	0	13.92	0	0	3.74	7.48	20.28	47.03	34.29
N-2	41.76	0	0	22.44	3.74	3.74	27.40	44.39	39.10
N-3	55.68	55.68	55.68	22.44	22.44	22.44	22.10	37.49	31.43
N-4	41.76	41.76	13.92	22.44	29.92	22.44	19.52	47.04	35.00
N-5	0	0	0	0	0	3.74	19.00	35.48	40.05
N-6	0	0	0	0	3.74	0	23.05	42.47	39.24
N-7	13.92	55.68	X	29.92	71.06	X	22.23	10.10*	X
N-8	0	13.92	13.92	0	7.48	7.48	22.15	50.22	42.02
N-9	13.92	13.92	0	11.22	11.22	0	20.19	50.32	33.20
N-10	69.60	27.84	13.92	37.4	18.70	14.96	22.38	49.20	29.32
N-11	0	0	0	0	0	3.74	27.02	54.47	40.55
N-12	0	0	0	0	0	0	23.11	49.45	43.10
N-13	27.84	27.84	27.84	18.70	18.70	18.7	8.39	53.25	39.34
N-14	27.84	41.76	X	33.66	56.10	X	20.52	23.15*	X
N-15	13.92	0	0	7.48	3.74	3.74	20.47	50.30	33.36
N-16	0	0	0	3.74	3.74	7.48	19.38	53.58	21.25
N-17	13.92	0	0	7.48	0	0	18.35	51.31	33.03
N-18	0	0	0	3.74	7.48	0	25.00	47.52	33.24
N-19	0	27.84	0	0	14.96	7.48	16.58	53.02	37.58
N-20	27.84	0	0	14.96	0	0	20.51	44.50	34.10

Note: N = Norfolk; G = Groton
"n" = Sum of Symptom Scores on Nausea Subscale
"o" = Sum of Symptom Scores on Oculomotor Subscale
"d" = Sum of Symptom Scores on Disorientation Subscale
"N" = Weighted Nausea Factor Score [(n) x 9.54]
"O" = Weighted Oculomotor Factor Score [(o) x 7.58]
"D" = Weighted Disorientation Factor Score [(d) x 13.92]
Total Score = [(n) + (o) + (d) x 3.74]
X= Subject Dropped from Evaluation; (*) = Time Subject Was Removed

APPENDIX K:

RESULTS OF VESUB TEE SIMULATION SIDE EFFECTS ASSESSMENT (Continued)

Transformed Scores After Scenarios and Time in HMD

Ss #	"D"			Total Score			Duration (Min.Sec)		
	Scenario			Scenario			Scenario		
	1	2	3	1	2	3	1	2	3
G-1	27.84	27.84	27.84	22.44	26.18	29.92	20.38	51.25	39.48
G-2	0	13.92	13.92	3.74	29.92	11.22	21.51	49.48	36.39
G-3	0	0	0	0	0	0	23.47	50.47	36.56
G-4	0	0	0	0	11.22	7.48	32.39	54.57	37.42
G-5	13.92	13.92	41.76	14.96	29.92	37.4	25.41	59.55	43.30
G-6	0	0	0	0	14.96	14.96	19.06	57.32	43.46
G-7	13.92	13.92	13.92	14.96	33.66	14.96	28.40	61.01	36.38
G-8	0	0	0	0	0	0	19.36	39.03	33.36
G-9	13.92	13.92	0	7.48	11.22	0	20.19	63.00	33.58
G-10	0	0	0	11.22	11.22	14.96	18.47	60.01	39.21
G-11	0	27.84	27.84	0	33.66	18.7	25.04	54.48	43.17
G-12	13.92	0	0	7.48	3.74	0	20.45	63.00	40.04
G-13	13.92	13.92	41.76	7.48	18.7	33.66	22.58	54.54	40.54
G-14	0	27.84	0	3.74	18.7	3.74	35.19	54.30	42.31
G-15	0	0	0	3.74	0	3.74	27.39	50.45	38.14
G-16	0	0	0	0	3.74	3.74	18.19	46.47	33.28
G-17	0	0	0	0	0	0	31.00	54.30	35.36
G-18	0	41.76	13.92	0	22.44	3.74	18.57	53.36	39.22
G-19	0	0	0	11.22	14.96	3.74	21.48	51.55	35.08
G-20	27.84	13.92	13.92	14.96	14.96	18.7	21.42	48.10	34.25
G-21	0	13.92	27.84	7.48	22.44	29.92	18.01	42.49	34.39
G-22	0	13.92	0	3.74	14.96	3.74	18.00	49.29	35.06

Note: N = Norfolk; G = Groton
"n" = Sum of Symptom Scores on Nausea Subscale
"o" = Sum of Symptom Scores on Oculomotor Subscale
"d" = Sum of Symptom Scores on Disorientation Subscale
"N" = Weighted Nausea Factor Score [(n) x 9.54]
"O" = Weighted Oculomotor Factor Score [(o) x 7.58]
"D" = Weighted Disorientation Factor Score [(d) x 13.92]
Total Score = [(n) + (o) + (d) x 3.74]

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